LEHIGH CEMENT

CONCRETE *for* TOWN *and* COUNTRY

N° 8

CONCRETE *for* TOWN *and* COUNTRY

A SERVICE BOOK OF INFORMATION FOR THOSE INTERESTED IN PERMANENT IMPROVEMENT *in* TOWN AND COUNTRY

LEHIGH CEMENT

THE NATIONAL CEMENT

Published by

LEHIGH PORTLAND CEMENT COMPANY

ALLENTOWN, PA. CHICAGO, ILL. SPOKANE, WN.

Part one is a collection of photographs of actual uses of concrete. It shows the possibilities of concrete in town and country.

Part two supplies practical information on the uses of concrete. By details and suggestion it gives the prospective builder a clear conception of good practice. Included with these details are tables which show the materials necessary. Quantity of cement is often referred to in barrels. As four sacks make one barrel, these two designations should not be confused. Five barrels of cement equal twenty sacks. Sand and stone are usually sold by the ton. The references are in cubic yards due to the variation in weights of different aggregates.

Part three explains the fundamental principles of concrete and the proper use of cement. Tables have been included for convenience and the spirit of Lehigh Service has been incorporated with the idea of guiding to best results the users of Lehigh—*the National Cement.*

L E H I G H
THE NATIONAL CEMENT

PRINTED IN THE UNITED STATES
OF AMERICA BY
WM. F. FELL CO., PHILADELPHIA

Foreword

THIS country was not the first to know the merits of concrete construction nor to use concrete in a modern way. But in characteristically American fashion we have advanced beyond all other nations of the world in the production of cement and its use in the form of concrete. In the face of this fact, however, there are many who do not yet realize what a valuable contribution concrete has made to the resources of this country and the still greater benefits that are to come with its further development.

The wide range of usefulness and adaptability of concrete can best be visualized by illustrations. That is why part of this book is largely a picture story, and for the same reason views have been liberally used throughout. Nor are these pictures merely dreams of what can be made of concrete—they are made from actual photographs of concrete work which has been done.

Concrete has been a great medium for efficiency in city, town, and country. Simplicity of use, wide-spread availability of materials, and comparatively low cost are its principal attractions.

Concrete is as nearly permanent as a building material can be.

Concrete provides the highest possible degree of protection against fire.

Firesafeness, health, comfort, economy, security, are all related to each one's personal welfare and interest.

The fire menace of the automobile is reduced to a minimum if the machine is housed in a concrete garage.

Concrete has maintenance built into it.

Concrete does not have to be repaired, rebuilt, or painted.

Concrete represents in the truest sense of the word an investment instead of an expense in building construction.

In town and country, in all the varied lines of American industry, concrete has almost countless uses.

To be practical a home must be a house that will endure, that can be kept warm in winter, comfortably cool in summer, dry in all weather.

The manufacturing plant requires structures that will safeguard its workmen; that will be free from excessive vibration; that will provide light, healthful, comfortable surroundings.

Schools, hospitals, hotels, apartments, office buildings—any structures designed to accommodate great numbers of people, must be safeguarded against fire or other catastrophe.

Industrial buildings must not only represent security of investment but freedom from burdensome maintenance cost.

Permanent highways of concrete reduce distance as expressed in time so that outlying rural communities are in reality a part of the city or town.

Mining operations are made safe by the use of pre-cast concrete "timbers."

Railroad bridges are being made better, stronger, safer, and more enduring by the use of concrete.

Millions of acres of fertile land too wet to farm are being brought into productiveness by drainage through the medium of concrete tile.

Arid sections of the west are being reclaimed through irrigation. Huge dams and concrete-lined canals supply the water that gives these lands the magic touch of fertility.

Cows will produce better milk if they are housed in clean, comfortable, sanitary quarters such as concrete provides.

In the barnyard a clean concrete pavement for the animals to walk upon and feed from, and a clean, everlasting concrete watering trough, are simple yet typical examples of concrete's valuable use.

As conservers of natural resources, concrete barn and stable floors and manure pits represent trifling cost by comparison with the resulting savings.

The concrete silo makes green fields last twelve months in the year for the dairy farmer.

Who would want to return to the old town of splintering wooden sidewalks compared with the old town made new by concrete walks, drives, streets, and alleys?

What would our cities be today without the modern sewer systems of concrete construction, the gigantic concrete-lined reservoirs that insure pure and dependable water supply, the concrete improvements in parks and public recreation places—swimming pools, pavilions, tennis courts?

This book makes it clear that concrete making is not surrounded with burdensome requirements. When one realizes that in hundreds of manual training schools in the United States boys are engaging in various kinds of concrete construction as a vocational exercise, it is evident that no unusual experience is required to be a successful home worker in concrete. Beyond a certain point there must be applied a knowledge of engineering principles. Work of this type can be successfully done only by specialists in concrete construction. The fact remains, however, that any person of average intelligence who will follow simple directions can do quite pretentious work with concrete.

LEHIGH PORTLAND CEMENT COMPANY

The Story of Lehigh Cement

THERE is no more fascinating nor extraordinary romance of fact and human achievement in the whole wonderful history of modern industry than "The Story of Cement." The stupendous battle which man is waging against the mighty forces of nature can be well realized in the amazing story of the combination of science, labor, technical skill, and vast financial resources necessary to the manufacture of Portland cement.

Space will permit of but the briefest telling of this wonderful story. So intensely interesting is it in every particular that to send forth this comprehensive and practical volume on the manifold uses of cement without at least recounting the major steps in the process of manufacture would be a most flagrant omission.

"The Story of Cement" is the story of a modern miracle—the miracle of pouring a mountain through a hole $\frac{1}{40000}$ of an inch square. Impossible, you say? Then follow us but a few minutes and see with your own eyes this miracle-like achievement.

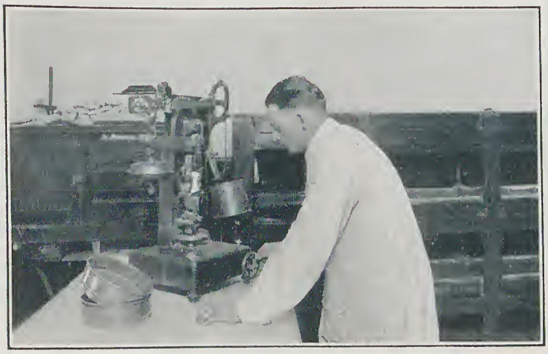
Before us looms a mountainside of solid rock, tremendous in its ruggedness. It is of two kinds—limestone and cement rock—the basic ingredients from which cement is made.

Into this rock giant drills cut deep cylindrical holes. These holes are packed with dynamite. When the series of holes has been charged and the last bit of wiring connected, the workmen hurry to places of safety. Then an electric button is pressed. There is a terrific explosion and the mountainside is torn and rent as by a violent convulsion.

When it is realized that about 600 pounds of this rock are required to make one barrel of cement, and that it is a small mill that does not have a daily production capacity of 5000 barrels, we begin to appreciate something of the magnitude of these blasting operations.

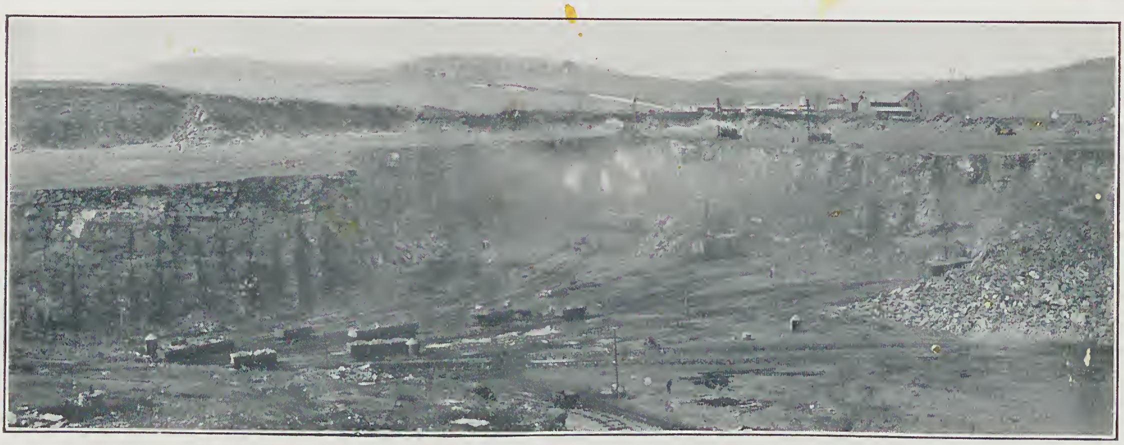
Before we go further, stop to consider how this great bulk of material is kept uniform, how the inequalities in the products of mother earth are compensated, how a finished product of known value results. This control must be exact without in any way curtailing the immense tonnage of production, and the elements entering into the manufacture must be defined to the minutest degree.

The laboratories are the brain of this great industry, and every step in the process is directed by the chemists, who must analyze the material from the core of the first diamond drill to the sample of cement taken from the car which has been shipped.



The physical laboratory

The chemical laboratory



The quarry

Huge steam shovels gather the quarried rock,—both limestone and cement rock,—loading it into cars which run by gravity to the base of the incline, there to be hauled to the top of the crusher house.

The jaws of the monster gyratory crusher reduce the boulders to a size that will pass a 6-inch ring and the battery of secondary crushers breaks it down to pass a 2-inch ring.

Then comes the hammer mill, running at 1100 revolutions a minute, granulating the stone and passing it on to the driers. Excess moisture must be evaporated from the stone to permit fine grinding, and these great revolving cylinders, heated to 1000 degrees F., deliver it absolutely dry.

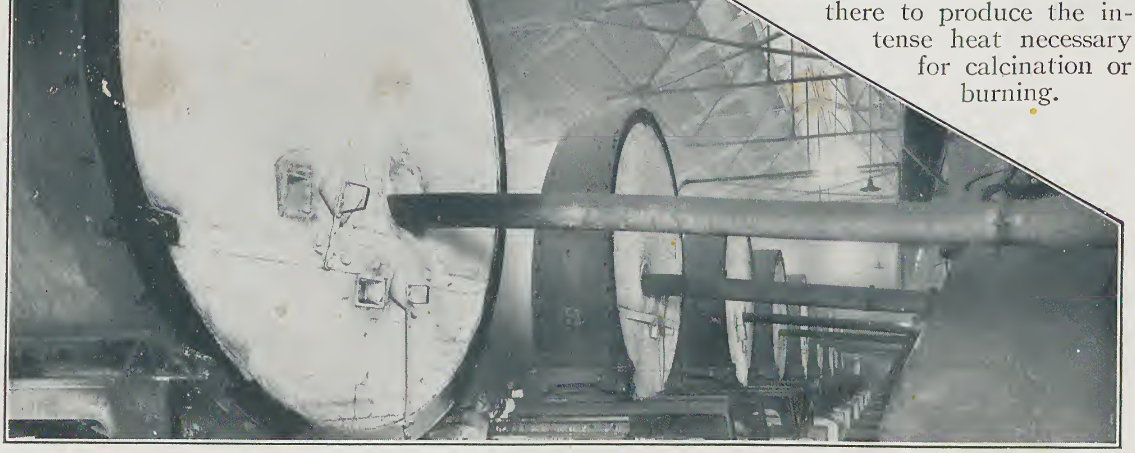
Twenty thousand ton storage bins then keep the stone, awaiting the results of the chemists' tests. According to the laboratory's instructions as to the proportions in which the two rocks are to be mixed, the material is delivered to the kominuter or ball mill.

Picture a battery of cylinders, each 6 feet in diameter and 9 feet long, turning at about 25 revolutions a minute, each hurling over its lining of offset steel baffle plates 6000 pounds of chilled steel balls 5 inches in diameter, crushing the stone to powder.

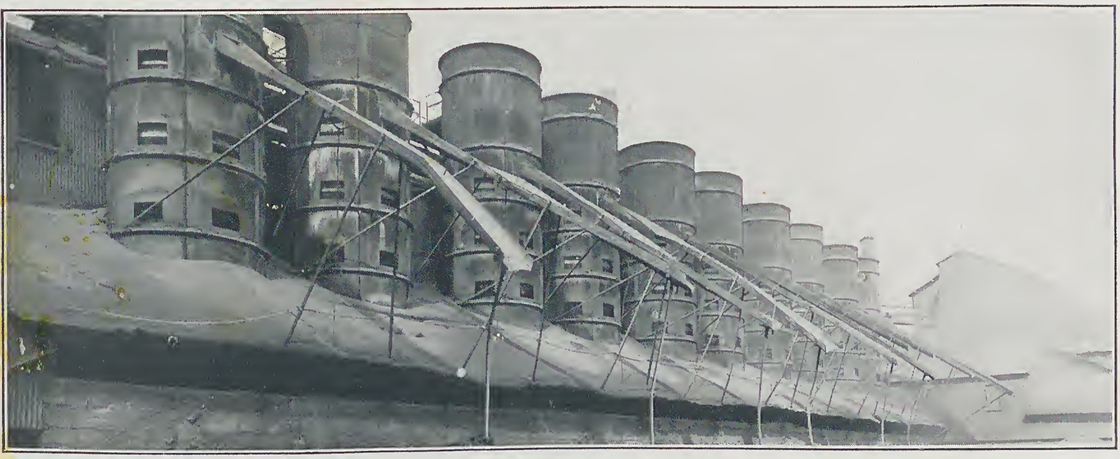
The tube mill reduces the material so that 80% of it will pass a 200-mesh sieve. A 200-mesh sieve has 40,000 holes to the square inch. Thus is achieved the miracle of passing a mountain through a hole $\frac{1}{40000}$ of an inch square.

Next come immense cylindrical kilns 8 feet in diameter and 125 feet long, which revolve slowly. These gigantic cylinders are set on a slight incline. Into the upper end is fed the powdered stone which, through the revolving motion, slowly works its way toward the lower end of the kiln, where occurs a most interesting and important process.

Into this lower end, forced by air pressure, is fed a stream of finely powdered soft coal. In a nearby building this coal is dried and passed through a battery of mills, which pulverize it so that it can be forced by air pressure into the kilns, there to produce the intense heat necessary for calcination or burning.



The kilns



The coolers

About 100 pounds of coal are required in the kiln to burn enough material to make one barrel of cement, and as a single kiln can turn out 600 barrels in twenty-four hours and the kilns are usually operated in batteries of eight or ten, the vital importance of coal in the cement industry will be realized.

Water boils at 212 degrees F. It takes about 3,000 degrees to make cement.

Slowly the raw powdered stone works its way toward the burning zone, and just as the stone is about to become a molten lava it drops from the kiln into a chilling chamber, where it changes from a white-hot mass to a hard black clinker.

The coolers are pictured, for they are intricate to describe and their part too important to overlook.

After it is cold to the core the clinker is weighed and raw gypsum is added to regulate the set or hardening of the finished product.

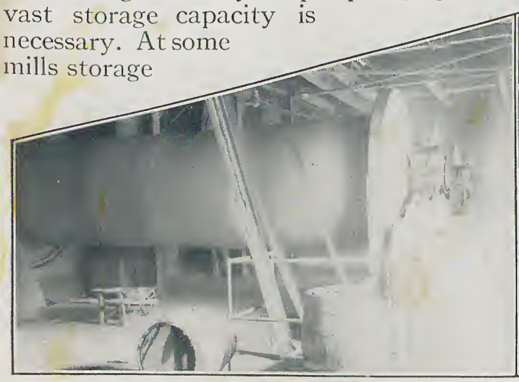
Then starts another round of crushing, pulverizing, and grinding through Griffin mills and tube mills, reducing the clinker so that 80% will pass through a 200-mesh sieve. This powder is Portland cement.

The cement is conveyed to bins, where it is held subject to the results of the chemical and physical tests carried on for at least 28 days. With the great daily output piling up, vast storage capacity is necessary. At some mills storage houses accommodate 700,000 barrels, or 2,800,000 sacks, for Portland cement is sold in sacks although priced by the barrel.

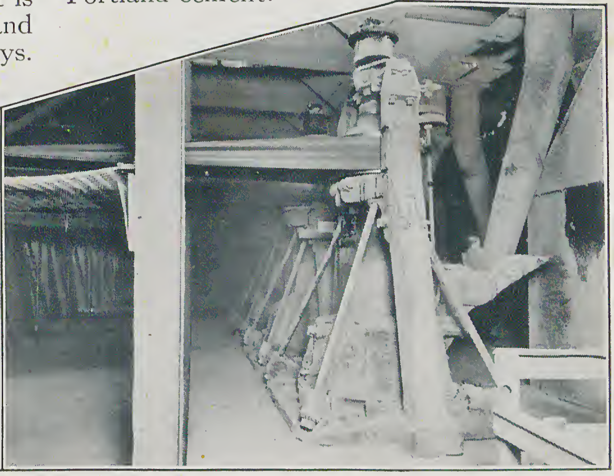
The sacks are filled on machines that automatically weigh the contents so that each package is sure to contain 94 pounds of cement. From the bagging machines belt conveyors carry the filled sacks direct to the cars.

No reference has been made to the immense power plant necessary to operate the heavy machinery needed to handle so refractory a material, but when it is remembered that a 5,000 barrel mill requires engines to produce 5,000 horse-power, some idea of the immensity of this plant can be formed.

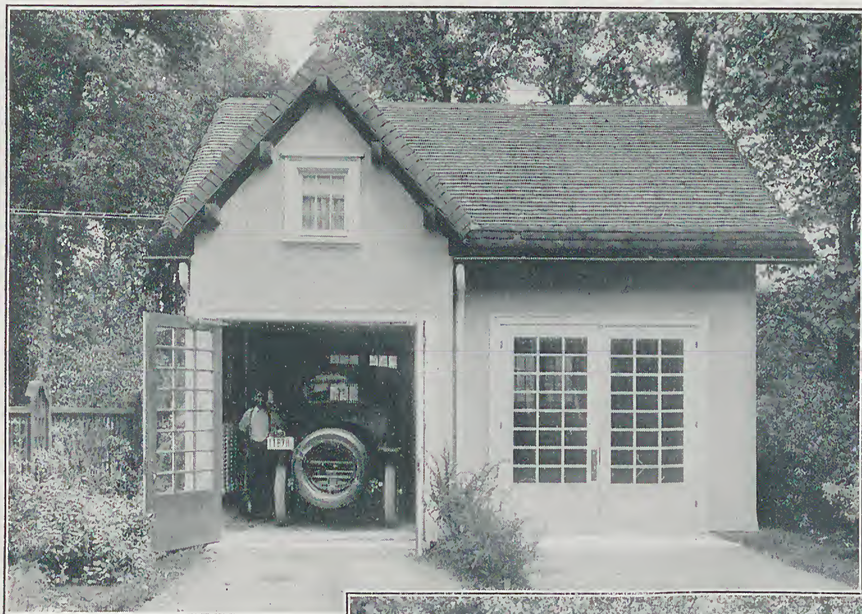
Tons of blasting powder—hundreds of tons of coal—thousands of tons of rock—millions of sacks—extensive buildings—hundreds of men and tremendous power are needed to operate a cement mill. Machine shop and store-rooms—belt and electrical shop—carpenters—foremen—superintendents—chemists and engineers—a virtual city in itself, representing many professions and trades all doing their part in the production of this wonderful modern building material—
Portland cement.



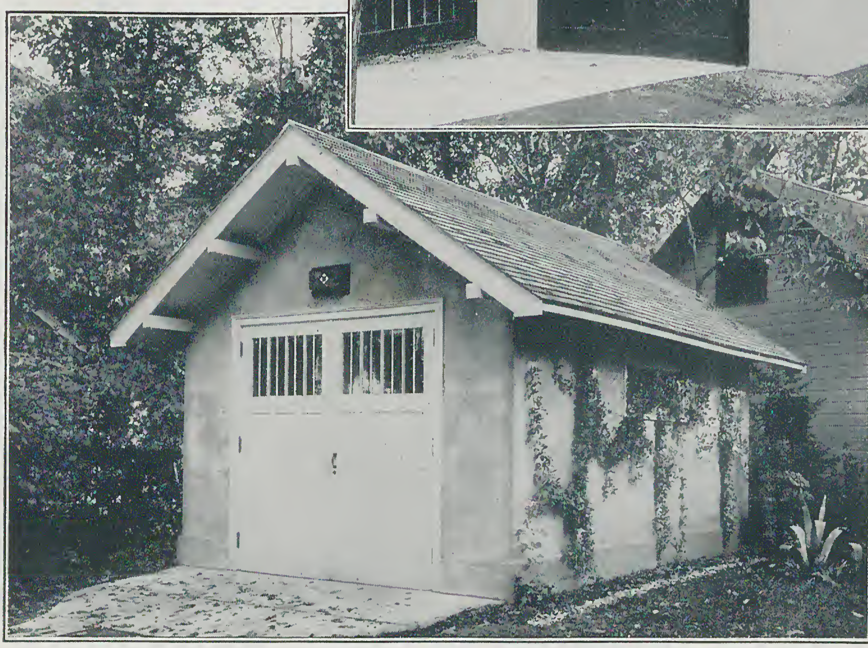
Tube mill

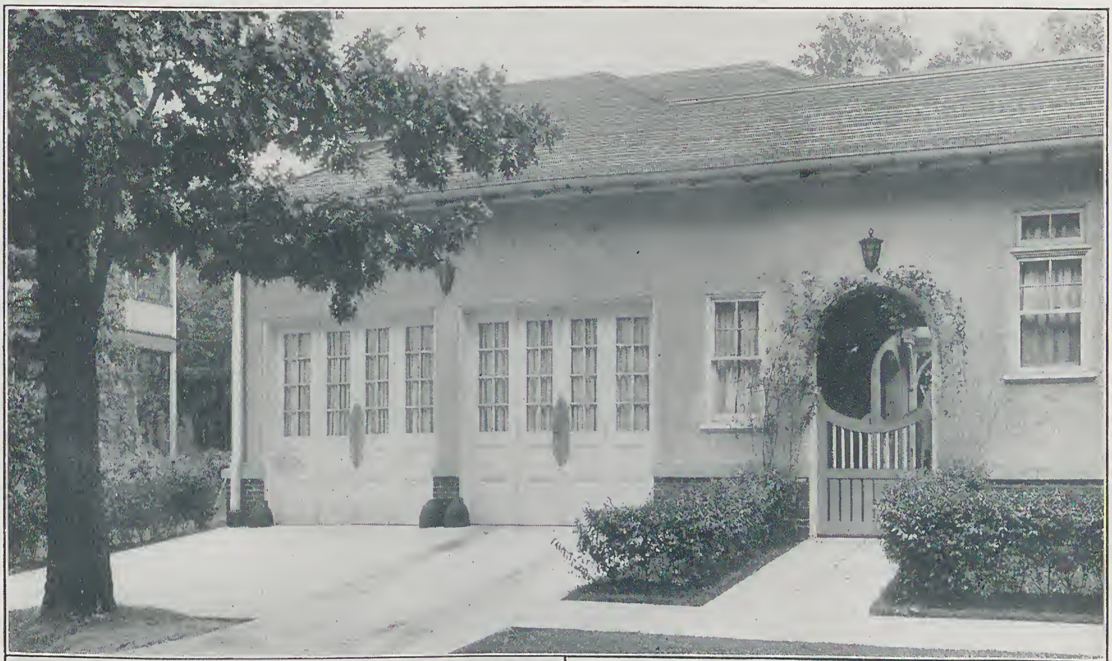


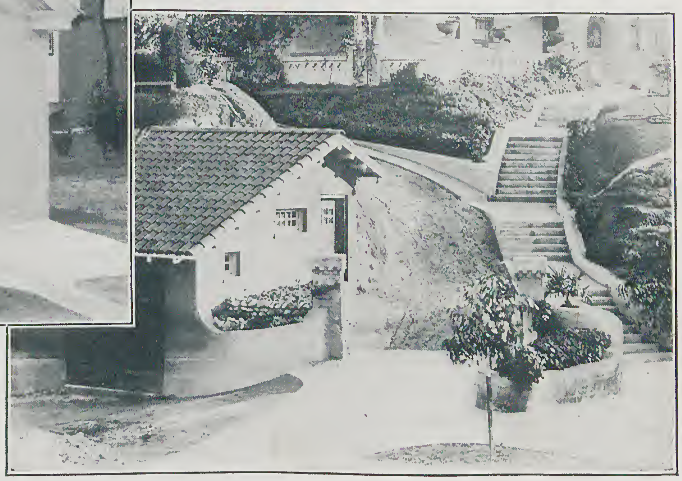
Griffin mills



GARAGES built of concrete are easy to clean, are moisture proof and weather proof, and, most important of all, fire proof. Lehigh cement in your concrete insures a quality material, and good concrete means permanence. Suggestions for garages will be found on pages 97 to 99.





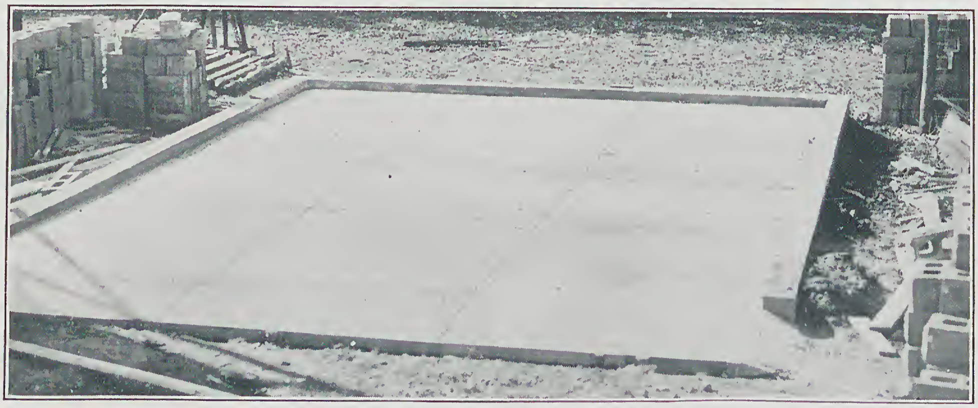


Concrete Garages

WITH approximately ten million automobiles and motor trucks in the country, the problem of housing them is important. Gasoline and the oils required to operate a car are highly inflammable and fire risks must be reduced by fire-safe construction. Concrete is the most adaptable building material for garage construction, insuring safety as well as lending itself readily to design in harmony with the architecture of the residence.

Concrete garages may be monolithic, concrete block, or stucco. Attention is called to the concrete driveways, washing floor, walks, and concrete stairways.

Specifications as to materials for a complete concrete garage are found on pages 97 to 99.



Garage Floors and Drives

A GARAGE floor made of concrete is easy to keep clean and materially reduces the fire hazard from dropping oils and greases. The illustration above shows a floor which was built prior to the erection of the superstructure.

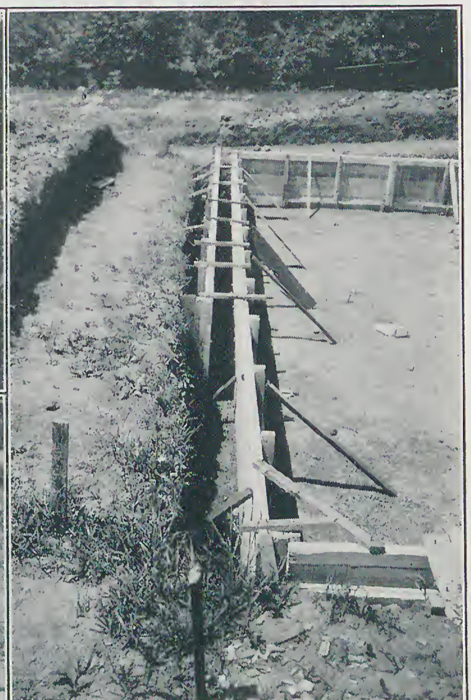
Driveways sometimes terminate in a washing floor directly in front of the garage, and are a valuable adjunct. Two parallel paved strips, each of a sufficient width to allow plenty of room for the car, are often used as a means of access to keep traffic from the lawn. This is an economical method of constructing an approach and is also serviceable.

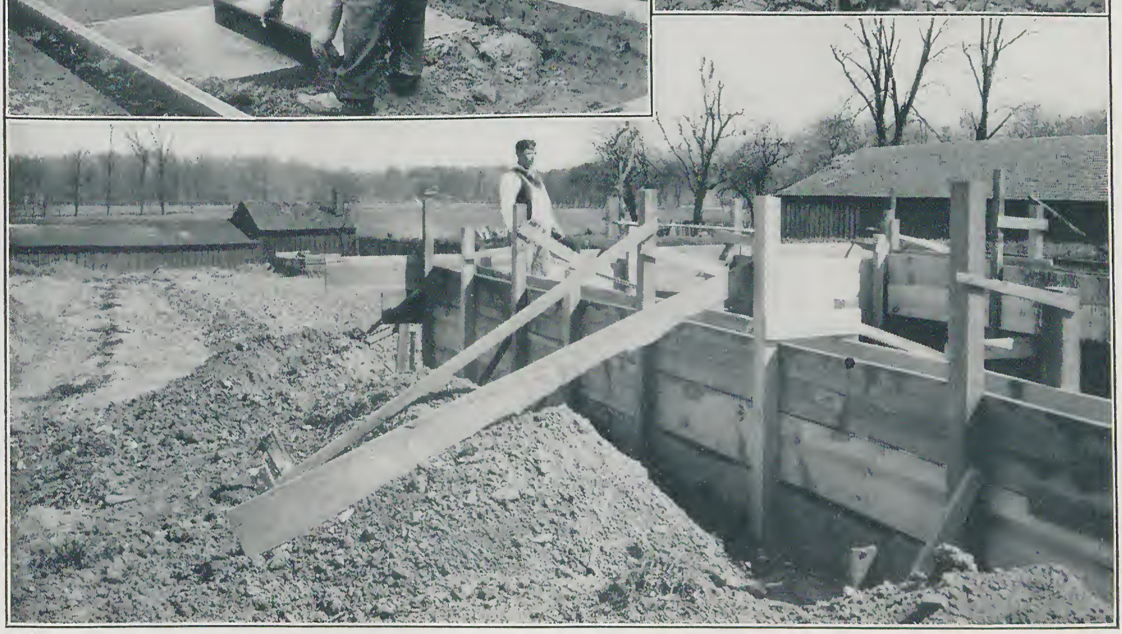
Pages 64 to 68, under "Floors, Walks, and Pavements," give working details.

Foundations and Walls

NO OTHER material is so extensively used for foundations as is concrete. It may be in the form of either monolithic construction or concrete block. Monolithic concrete is most adaptable for massive and irregular foundations. This does not mean, however, that concrete blocks are lacking in a wide range of adaptability. They are particularly suited to light foundation work, such as is required for houses, barns, and other town and country structures, because form work is unnecessary.

When the simple principles of concrete practice outlined under "Fundamental Principles," pages 153 to 185, have been observed, building a concrete foundation is one of the easiest types of construction work, requiring little cutting of lumber and being within the range of any one's ability.



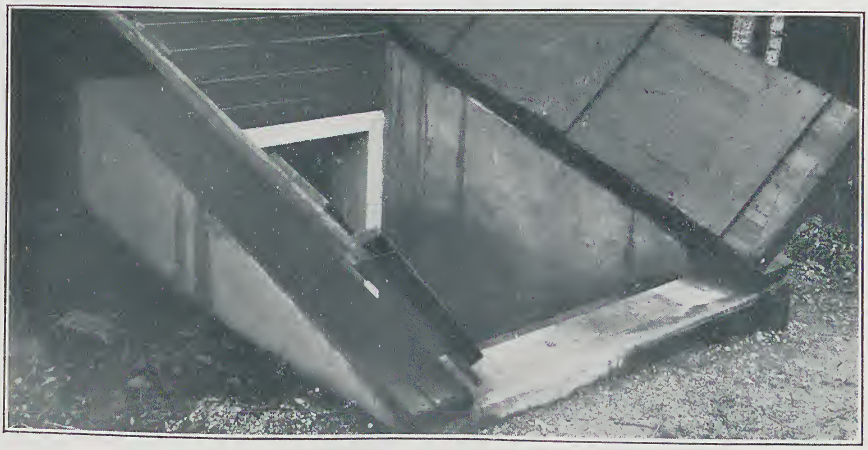


THE SIMPLICITY with which the minor classes of construction can be built is evidenced by the work which is being done by students the country over. Concrete sidewalks have proved their usefulness from the standpoints of economy in first cost, low maintenance, and qualities of safety of travel, cleanliness, and good appearance. The construction of both one- and two-course sidewalks is explained on pages 64 to 68.

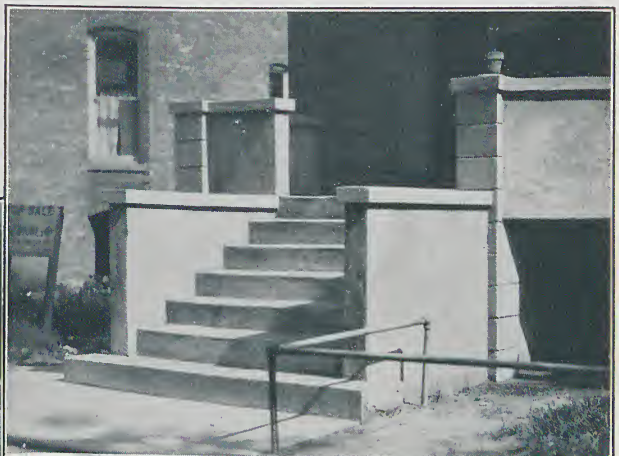
THE fundamental principles which must be observed to secure best results in constructing sidewalks are given on pages 153 to 185.

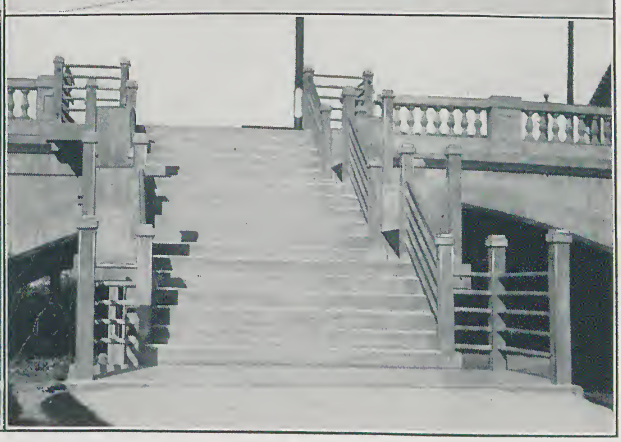
Steps and Stairways

CONCRETE steps are safe as well as clean, permanent, and of good appearance. A variety of designs to which concrete is adaptable in the construction of steps and stairways are illustrated. For long flights of terrace steps it is very important to provide a solid foundation, thus avoiding the cracking of the concrete. Except for intricate types, any one handy with tools can build the necessary forms shown on page 69.



CONCRETE lends itself admirably to the construction of permanent hatchways. The principles of construction are practically the same as those used for other stairways shown and foundations described on pages 57 to 62.

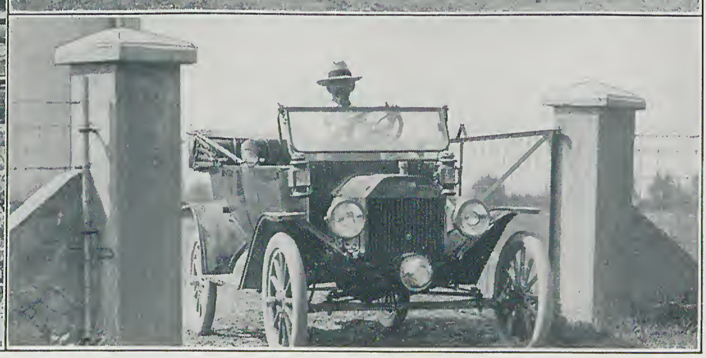


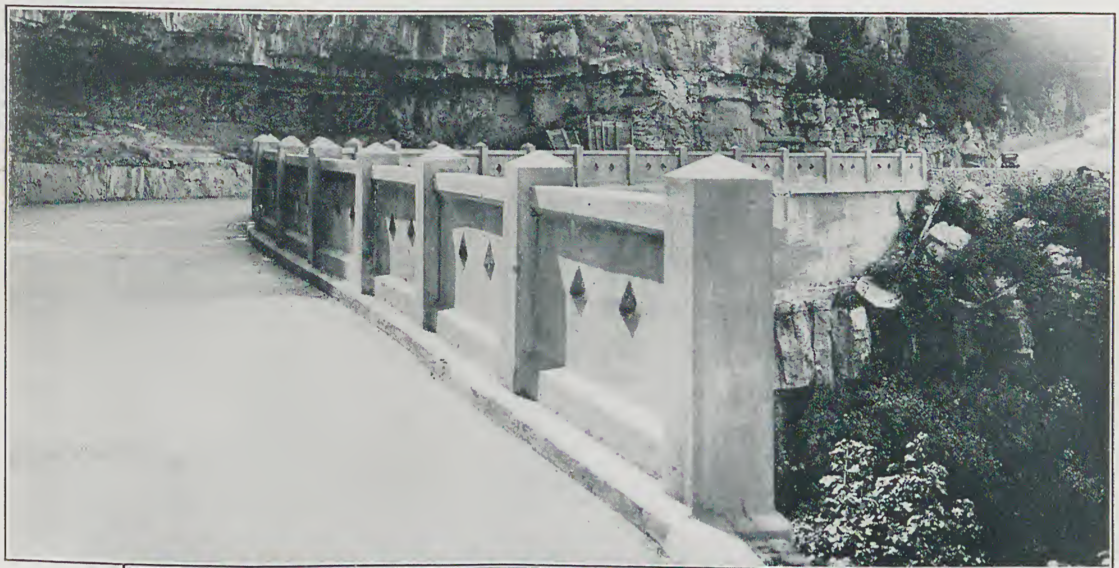


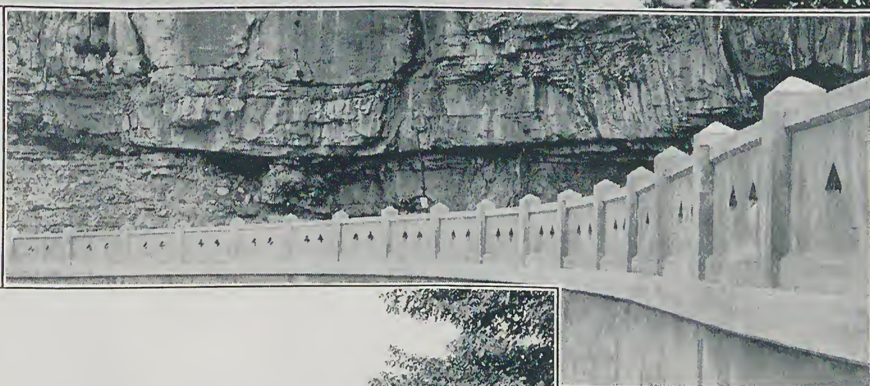
Fence and Gate Posts

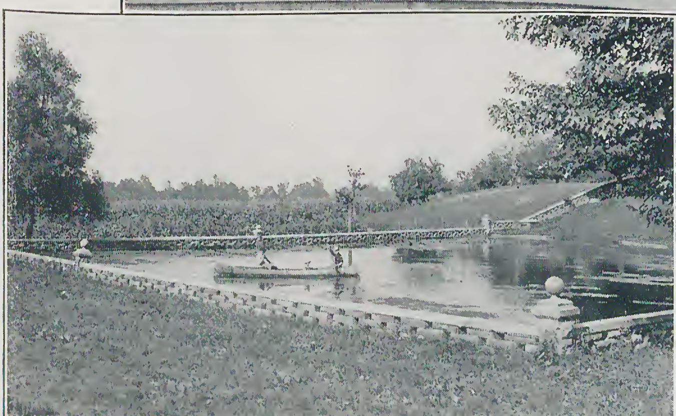
THE unpleasant job of renewing rolled fence posts year after year can be avoided. Concrete fence and gate posts are permanent. They are inexpensive and many styles can be built during spare time in sheltered places when weather conditions prohibit out-of-door work.

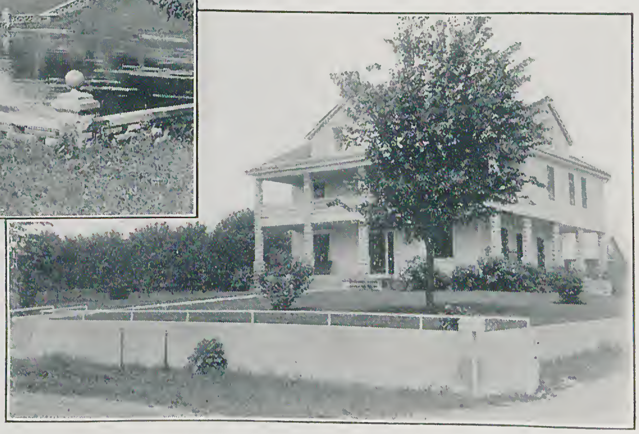
Information on post forms and construction will be found under "Concrete Products," pages 76 to 92.





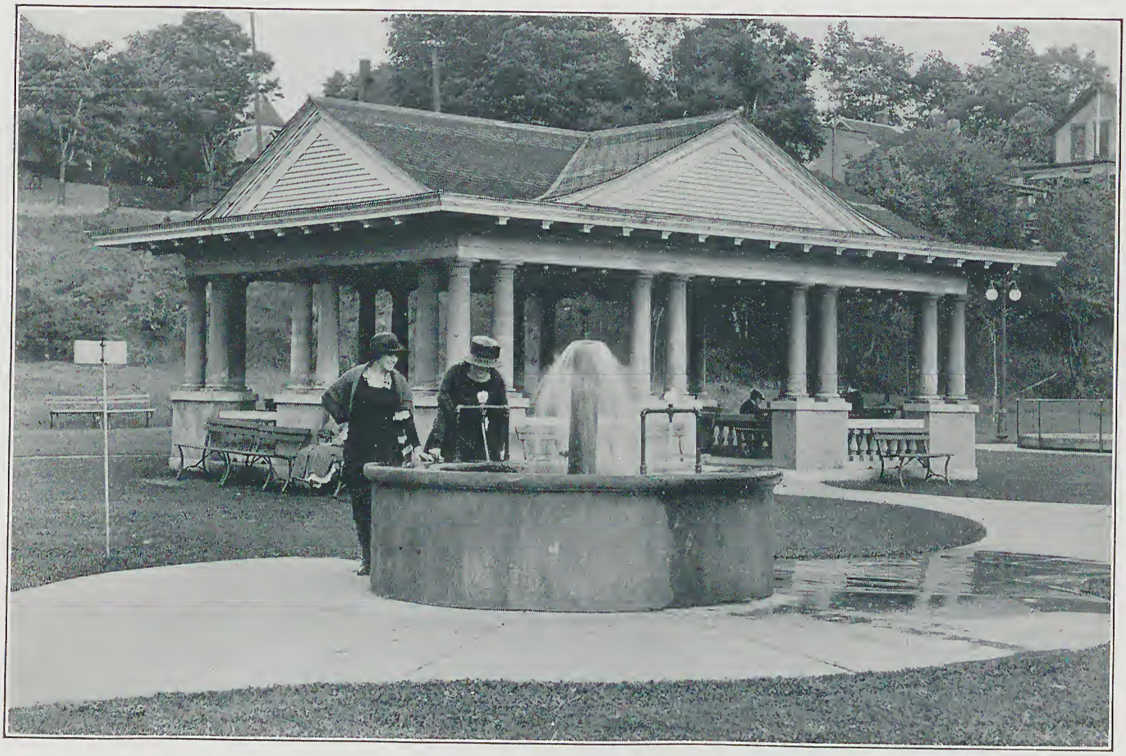






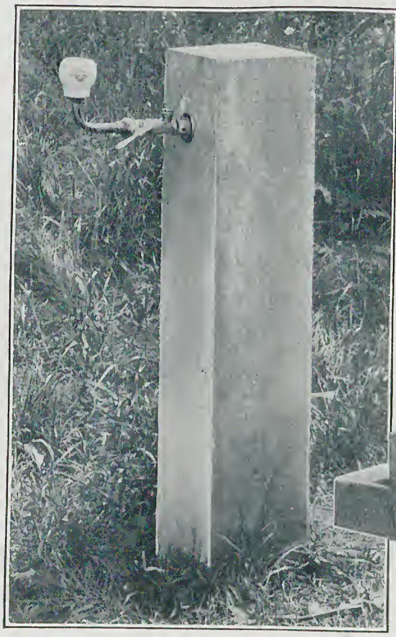
Concrete Enclosure Walls

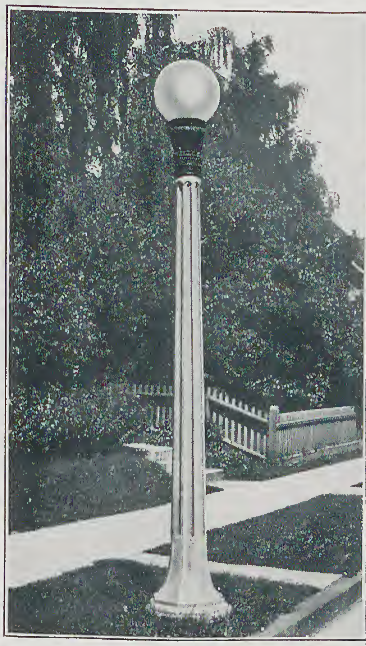
CONCRETE is used for a great variety of retaining walls, and these may be plain and simple, or may be as elaborate as taste and local conditions justify. In some of these examples the architectural possibilities of concrete in this particular field are well illustrated. Drawings and descriptions found on pages 88 to 92 are most complete, and can be used to great advantage in constructing this class of work.

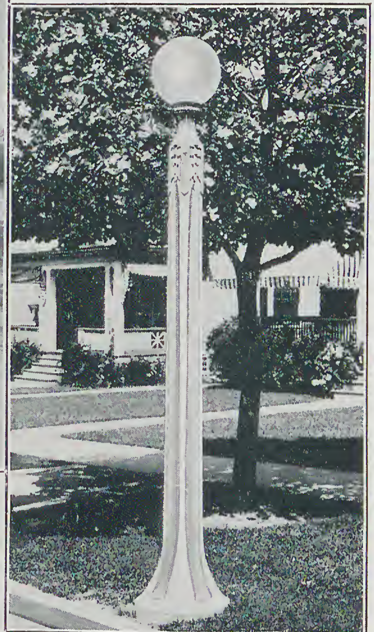


Bubbling Fountains

A CONCRETE bubbling fountain is a sanitary improvement, is inexpensive and attractive. It is adaptable for public parks, country clubs, seaside resorts, large farms, and even on the small home grounds. The exact size and shape depend upon the individual taste, and with a certain amount of care very attractive designs can be accomplished.

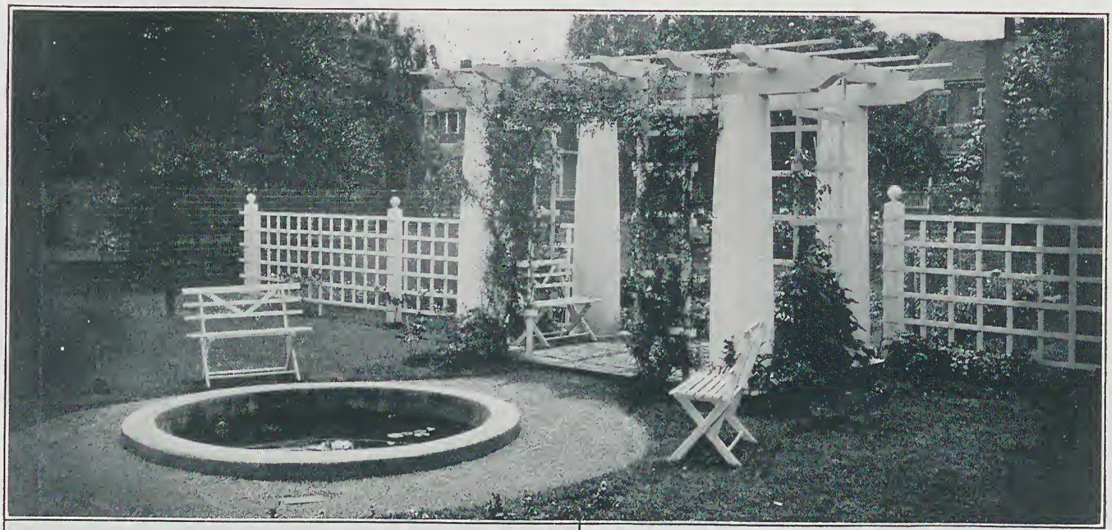


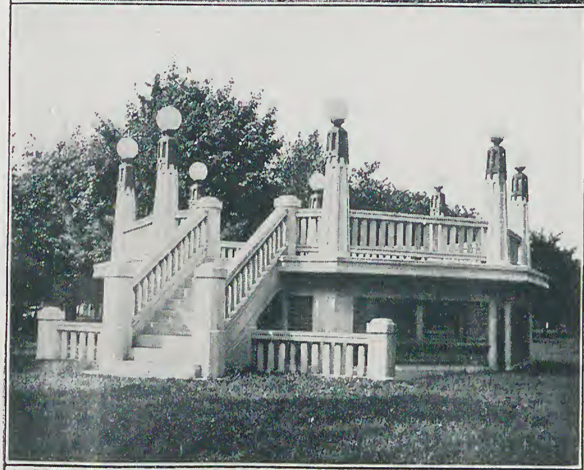




Concrete Standards

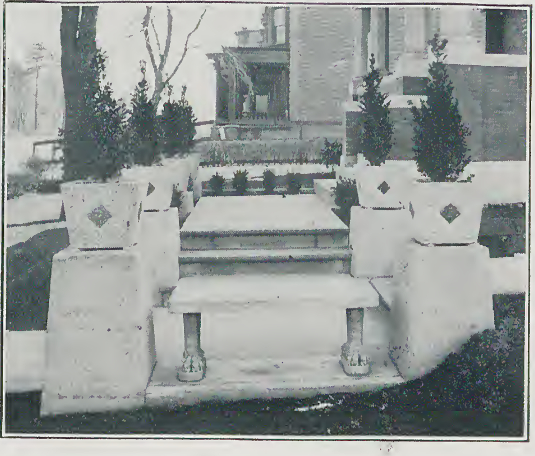
CONCRETE posts are superseding old wooden types which have to be replaced due to deterioration and cost of upkeep. Besides being ornamental, they are very serviceable, and are used for many purposes other than strictly lighting standards. Illustrated among this group is one serving as a street sign post. This type is being used to great advantage in the more progressive cities and towns. The type of construction is practically the same as that found on pages 84 to 92.

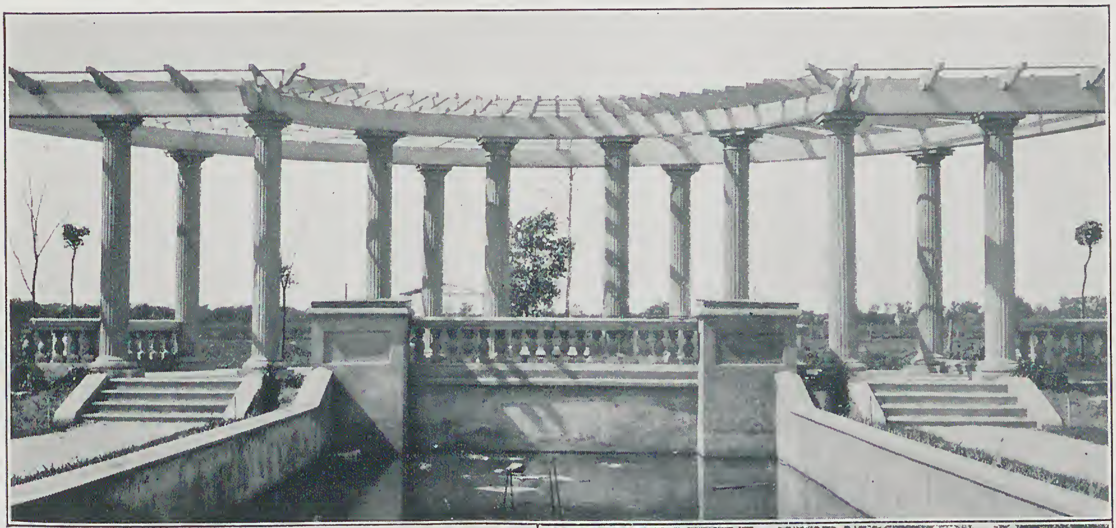




Civic Improvements

RECREATION centers and public parks are places of comfort, beauty, and happiness. To make them permanent as well as ornamental they should be constructed of concrete. No other material lends itself so readily to the diversity of designs. It tends to eliminate maintenance expense and keeps within bounds the cost of construction. Whether it be a bandstand, a pavilion, a lily-pond, or any other type of structure found in the garden, the park, or the entranceway, attractive designs can be economically developed by the use of concrete. See pages 76 to 92, under "Concrete Products," for designs, and also pages 153 to 185 for "Fundamental Principles," which will give the necessary information.

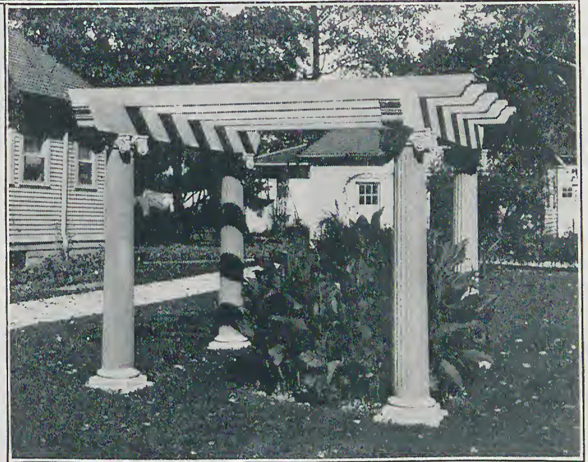


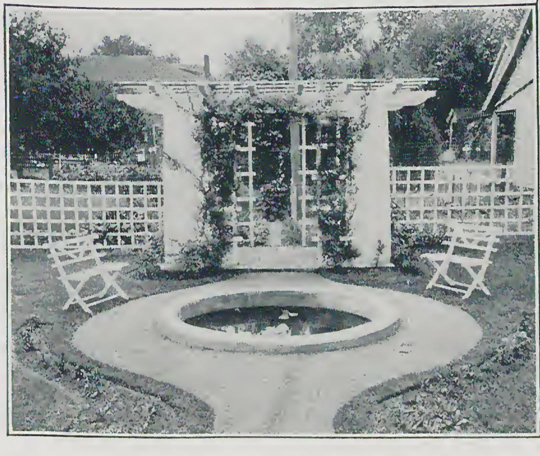


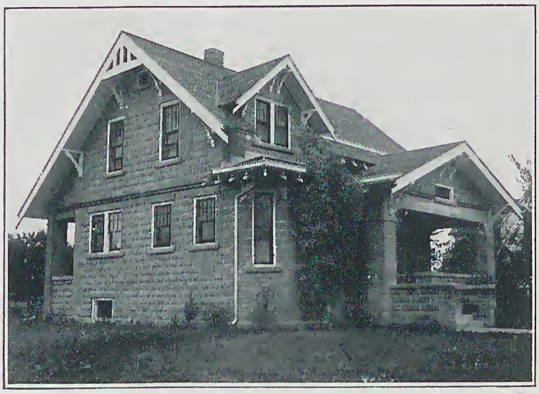
The Pergola

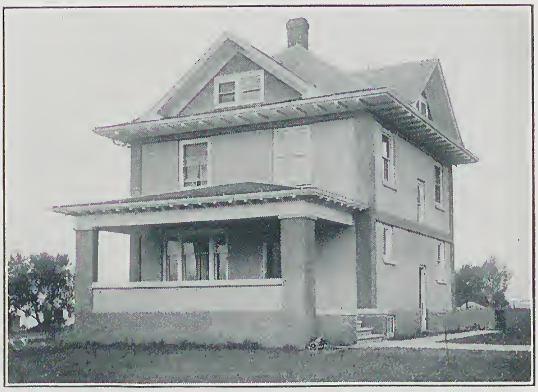
IN PRIVATE as well as public gardens the pergola as a decoration is becoming more popular. Covered with vines and flowers, new life and beauty are given to what may have been a barren spot. Concrete in this construction has proved its worth. The possibility of conforming with adjacent architectural design, as well as the selection of a great variety of surface treatments, is made possible with this material, while permanent and beautiful results can be attained.

The section on "Concrete Products," pages 76 to 92, as well as pages 153 to 185, on the "Fundamental Principles," will be found of material assistance in planning or constructing any practical pergola design.









Cement in House Building

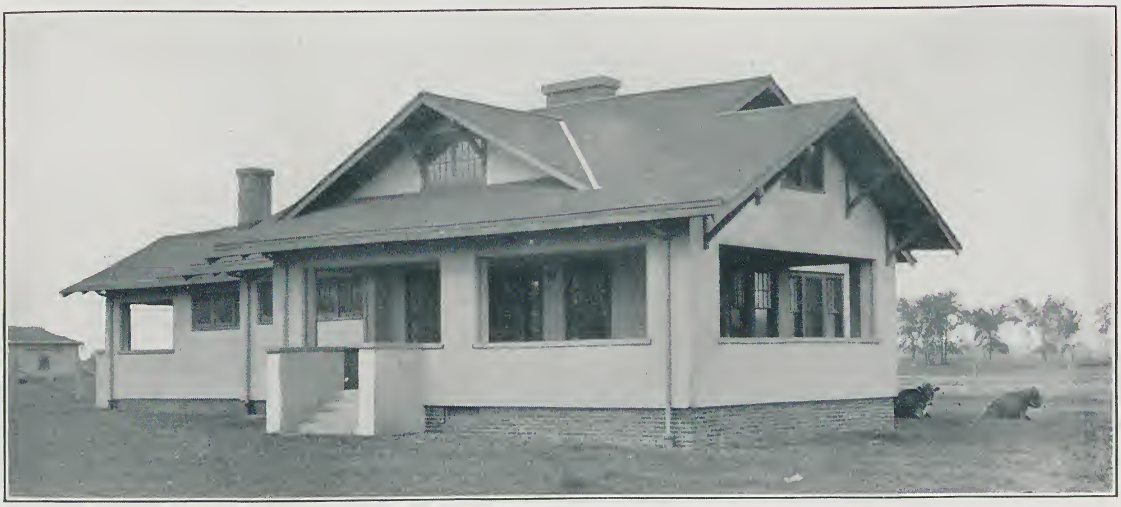
THE variety of ways in which cement for concrete may be used—monolithic, block, brick, stucco, and structural tile—give the architect all necessary latitude to produce any design or any type of architecture to which the material is suited. In addition to this the inherent qualities of concrete construction place this material in a class by itself because it is possessed of some individual and distinctive merits. Permanence means freedom from expensive upkeep—fireproofness means low insurance cost as well as safety. Both of these qualities are dominant in concrete.

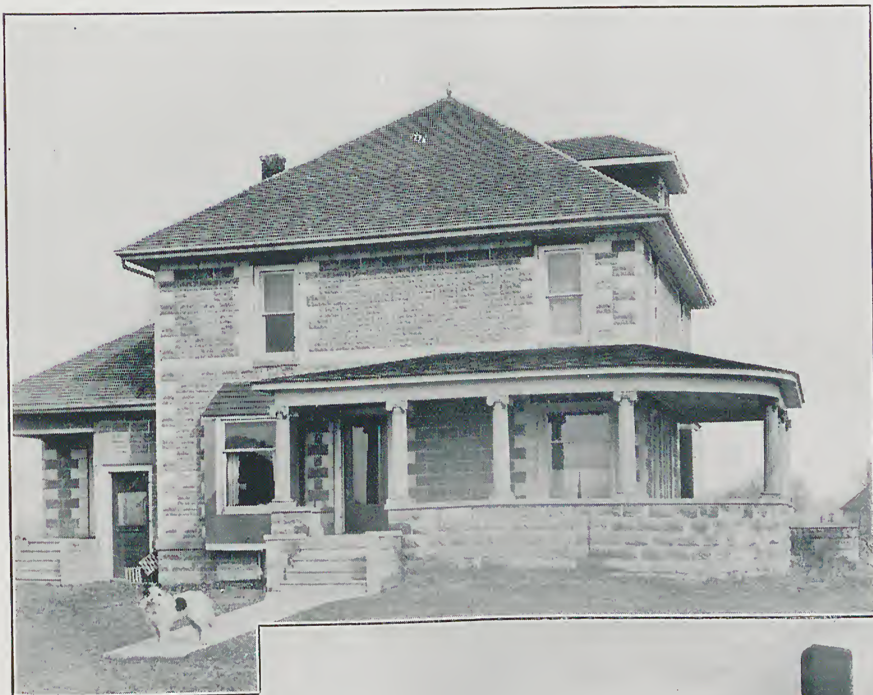
In order to appreciate the deficiencies of most houses in the country today we must remember that fire-proof construction has been the exception rather than the rule. Foundations are as nearly permanent as can be, yet the remainder of the structure is usually a firetrap.

Numerous systems of concrete house construction, with particular reference to the use of monolithic concrete, have been developed. The efforts in all cases have generally been directed toward perfecting a system of forms. These should have a wide range of adaptability that will permit rapid assembling and dismantling, facilitating speed of construction, and providing for many variations in exterior appearance.

New types of concrete block have been developed and older types improved. The early rock-faced concrete block has gone into the discard. Architects recognized it for what it really was—a base attempt to imitate natural stone. Modern concrete building block and concrete brick are distinctive products and rival, and in many cases excel, the finest cut stone.

This discussion of concrete for houses has not been presented with the expectation that the home worker will build his home of concrete by his own labor, but rather to encourage careful comparison of concrete with all other materials so that he can learn its advantages.

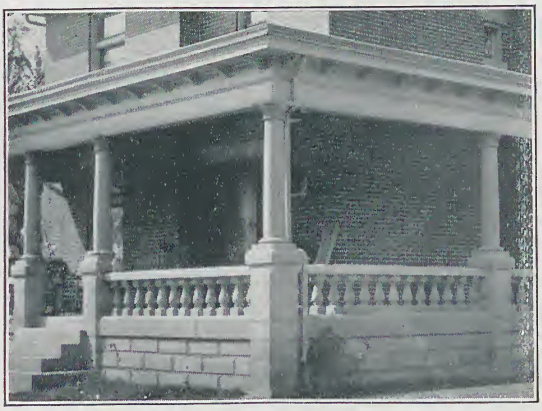




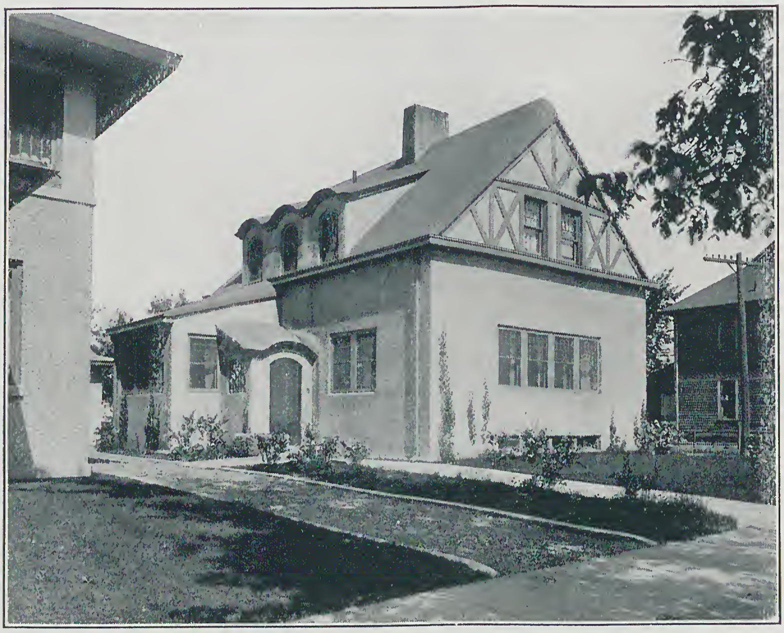
A concrete block residence finished with architectural trimstone.

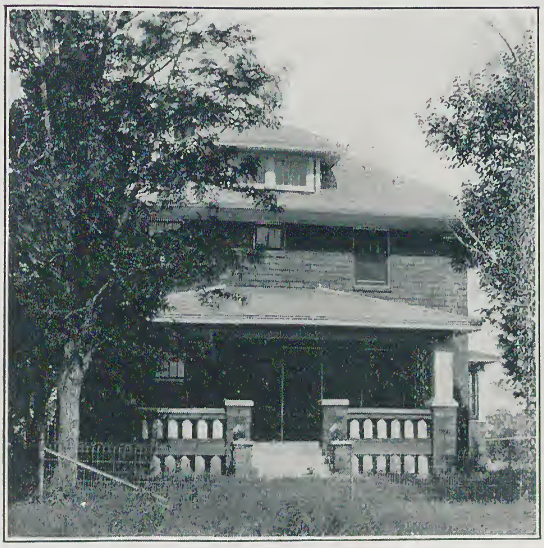
Stucco finish made from Lehigh Portland Cement is attractive and serviceable.

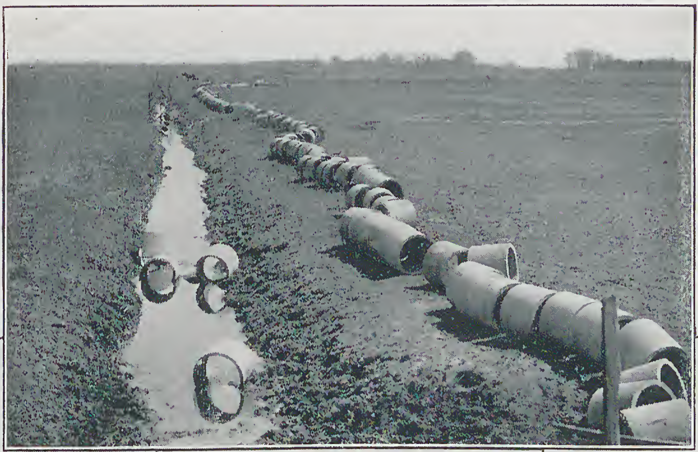
The monolithic house provided with an asbestos cement shingle roof represents the last word in modern home construction.



Porch posts, porches, and steps are permanent if built of concrete. Monolithic or block, columns, spindles, or similar precast units are attractive, economical, and everlasting.





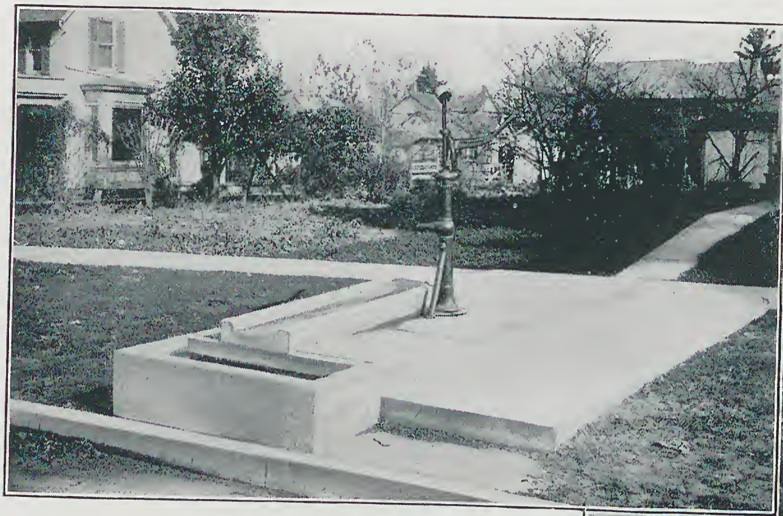


Land Drainage

LAND drainage has long been most effectively accomplished through the use of concrete tile. They are permanent, true to shape, therefore easy to lay, not subject to any disintegration from frost action, and provide a flow-line that is not likely to become obstructed. Further description may be found on pages 76 to 83.

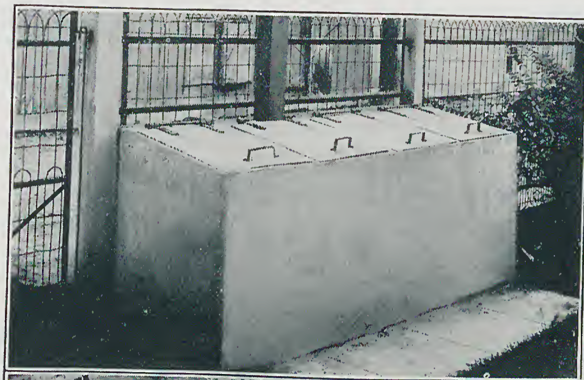
Concrete Rollers

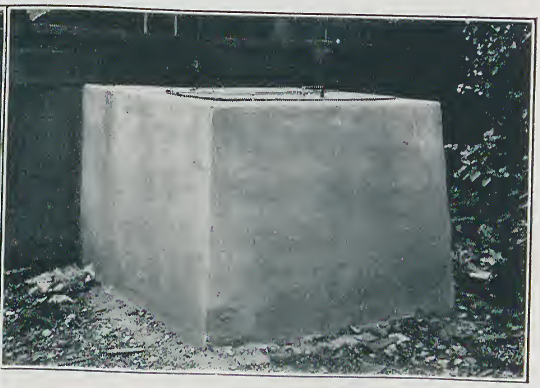
BESIDES the money saved, a certain pleasure is derived from the use of something that we have made ourselves. A roller is easy to make, practical to use, and will last a lifetime. Information on posts, pages 84 to 92, will help you make a roller.

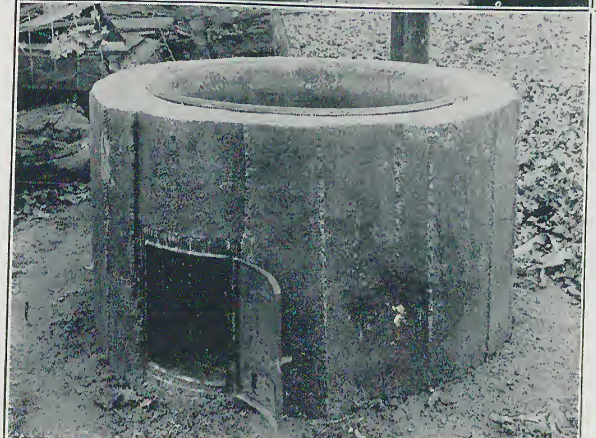


Well Covers and Linings

A CONCRETE well lining and cover will permanently insure against contamination by surface drainage. This simple safeguard to health should not be neglected where a well is the source of domestic water supply. The well with the wooden platform is never free from danger of contamination and should be replaced by following the suggestions on pages 122 and 123.



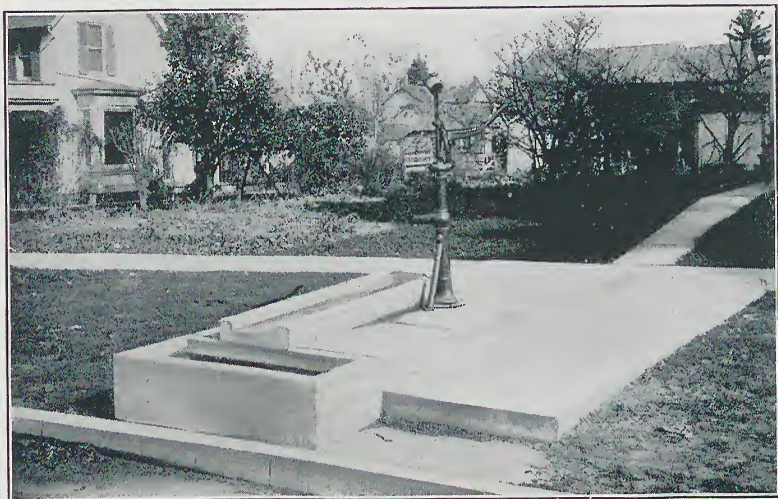




SMALL concrete containers are of considerable advantage to the present-day farmer.

Such containers are fire-proof and leak-proof, and can be easily constructed. Cleanly and sanitary, they are especially valuable where there is an automobile or a tractor for the storage of oils and gasoline.

The concrete cooker shown at the left was made by setting an iron kettle in concrete and building a stove compartment beneath.



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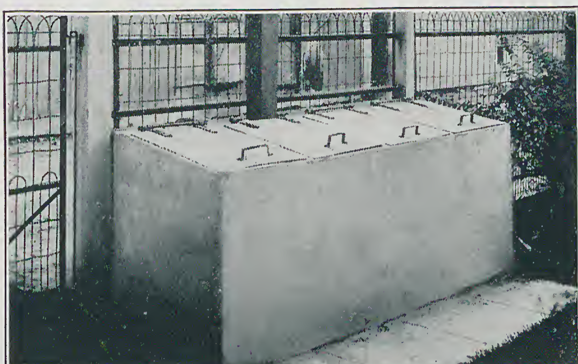

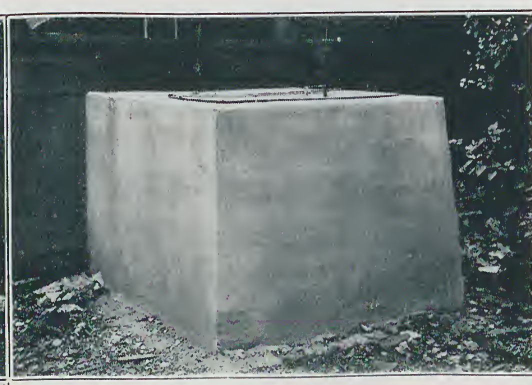

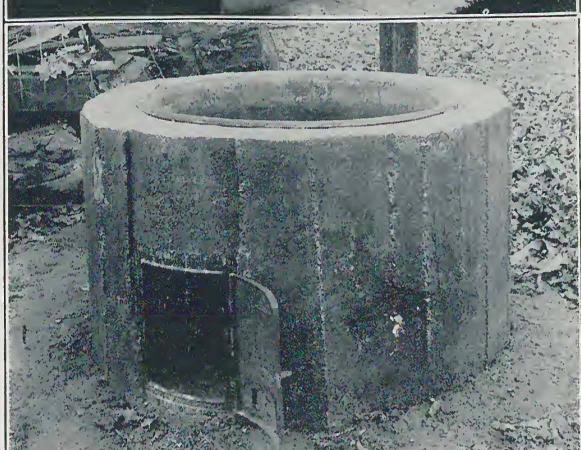

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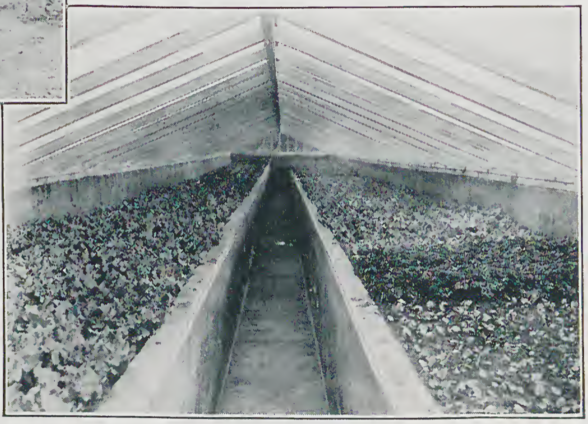
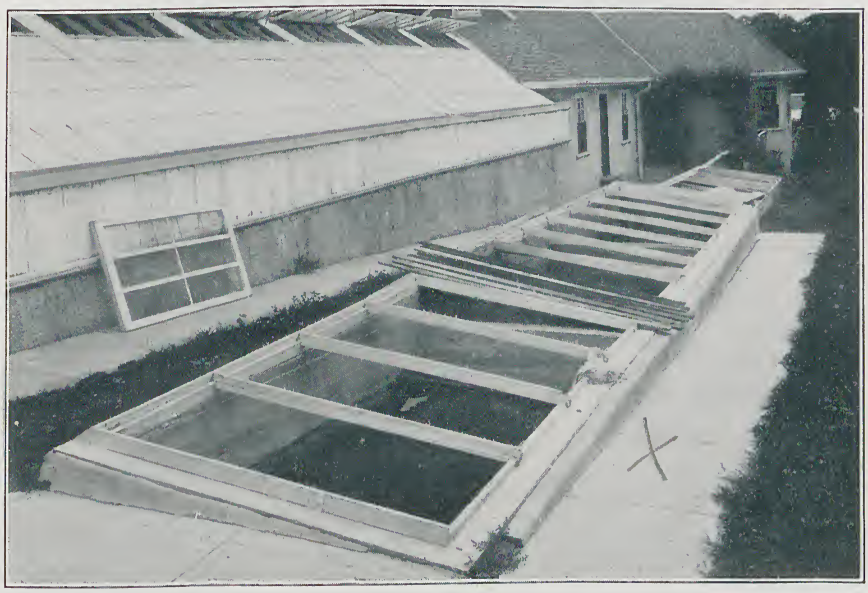
The Greenhouse

PAGES 64 to 68, describing the construction of walks, and pages 57 to 62, on foundations and walls, give the fundamentals for successful greenhouse construction. Wooden buildings cannot last in the moisture-laden atmosphere of the greenhouse. Concrete is replacing old-fashioned wooden walks and walls, and is being used in the construction of the interior equipment.



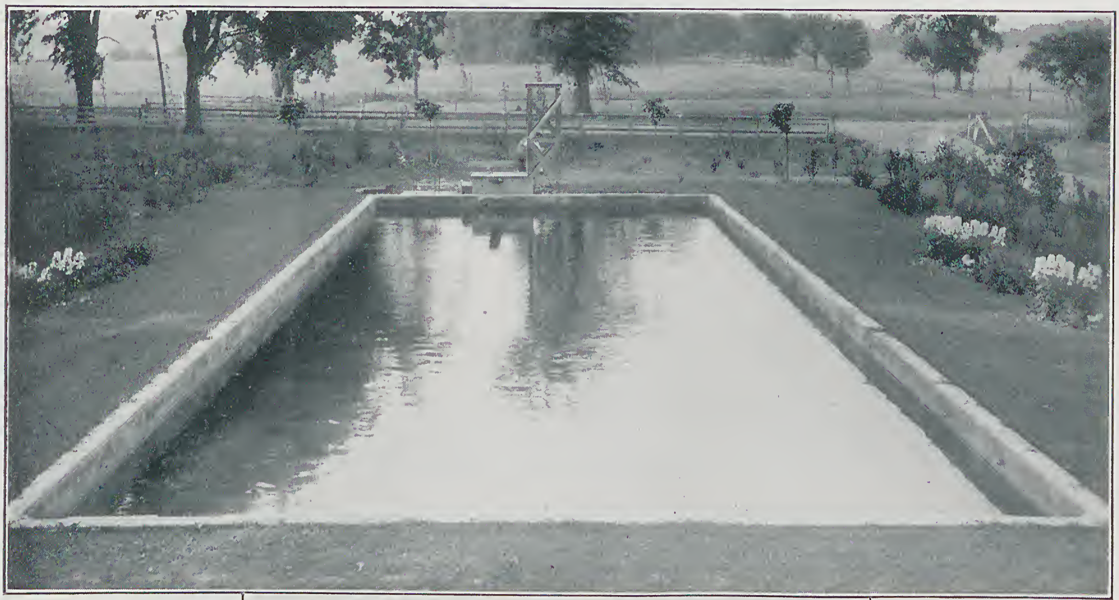
Temperature control is aided, due to the insulating qualities of concrete, and the wooden greenhouse is becoming obsolete, giving way to the modern concrete structure.

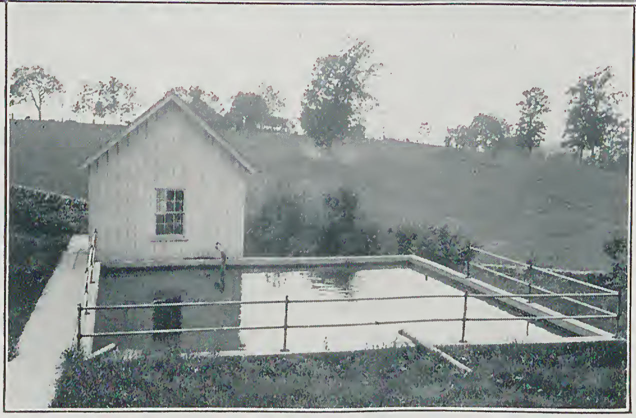


Hotbeds and Cold-Frames

AN EASY way to make the home garden last practically twelve months a year is to have a hotbed or a cold-frame. Another use is in advancing early spring plants. The difference in name is merely to indicate the manner in which it is operated. The average hotbed built of lumber or logs is a temporary structure, due to rapid decay. After a year or two it has to be rebuilt at considerable cost of time and material. Concrete, not being subject to rot or other depreciation, prevents such waste of labor and material. Once built it is always built.

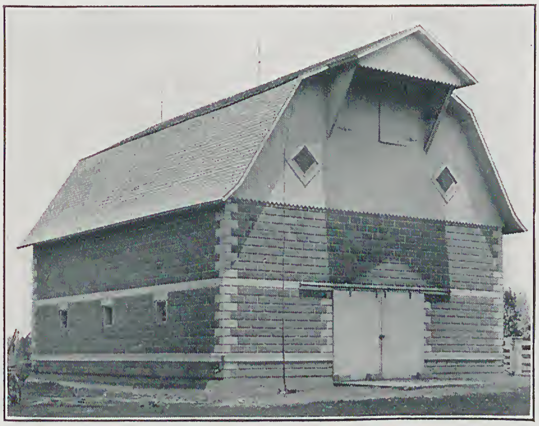
The construction principles, with drawing and materials required, are found on pages 72 and 73, under "Hotbeds and Cold-Frames."

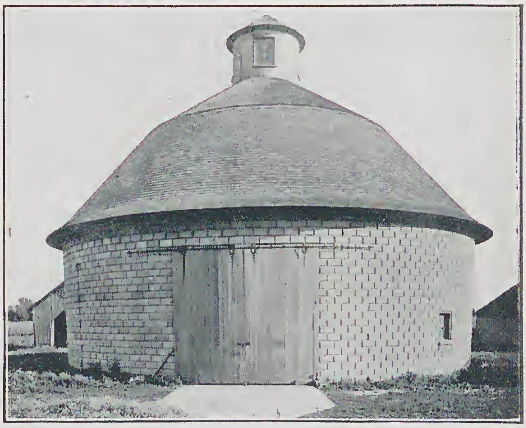




Swimming Pools

CONCRETE sand-boxes for the children to play in, wading-pools for them to paddle in, and swimming pools are desirable adjuncts of public parks and playgrounds, as well as of the country estate and country club. The construction of these outdoor amusement troughs is practically the same as for any concrete trough. Plans are shown on page 100. The lily pond is practically identical in construction with that of the swimming pool.

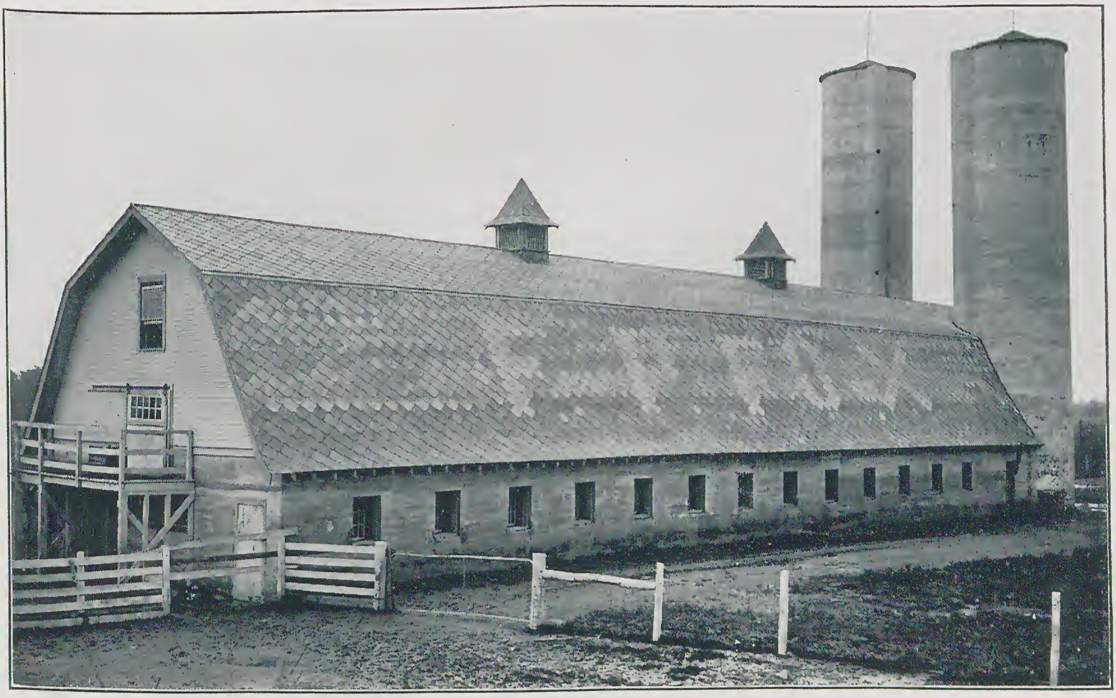




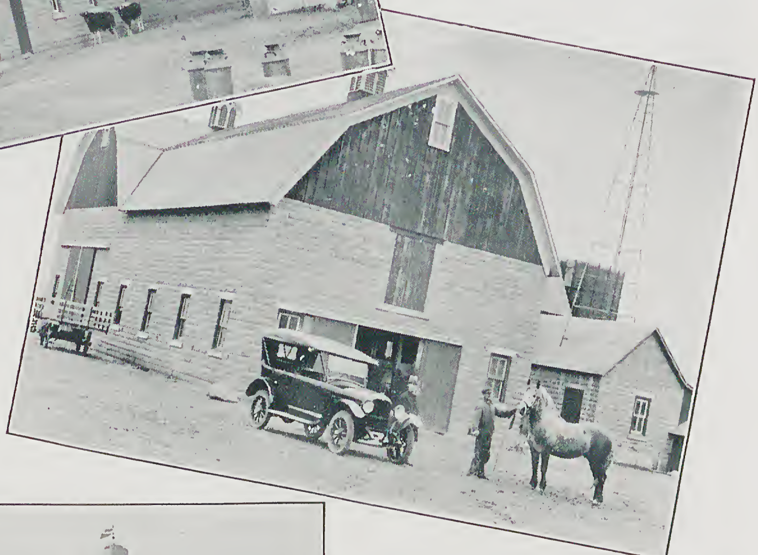
Concrete Barns

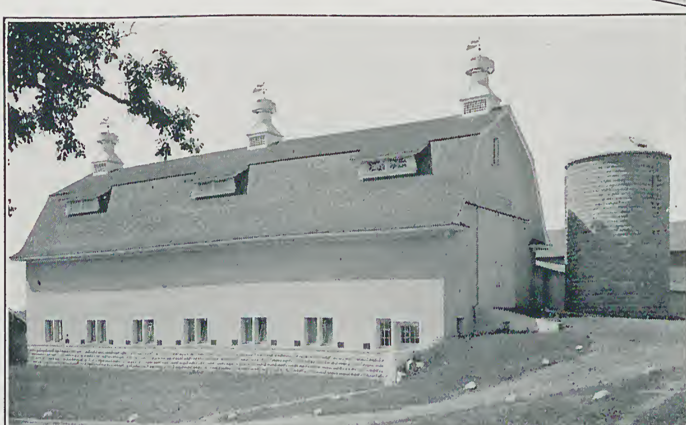
THE central structure of every farm is the barn. Whether it be for dairy cattle, to house live stock, or a general purpose barn, its importance among the farm structures warrants careful planning and the very best construction. Safe against fire, wind, and the elements, a concrete barn stands as a protection against a total loss of the harvest, the destruction of the dairy herd or the other live stock. By eliminating breeding-places it serves as a protection against marauding rodents. It keeps out the rat. It reduces the labor necessary to the operation of a farm, and makes possible a building of convenience and beauty. Beyond all, it is permanent.

The year's financial investment is safeguarded so thoroughly that everywhere more attention is being paid to the use of concrete in barn construction. A detailed design with more general information will be found on pages 146 and 147. The sections on "Foundations and Walls," pages 57 to 62, "Floors, Walks, and Pavements," pages 64 to 68, "Roofs," pages 106 and 107, as well as the general information under "Fundamental Principles," pages 153 to 185, will prove interesting reading.

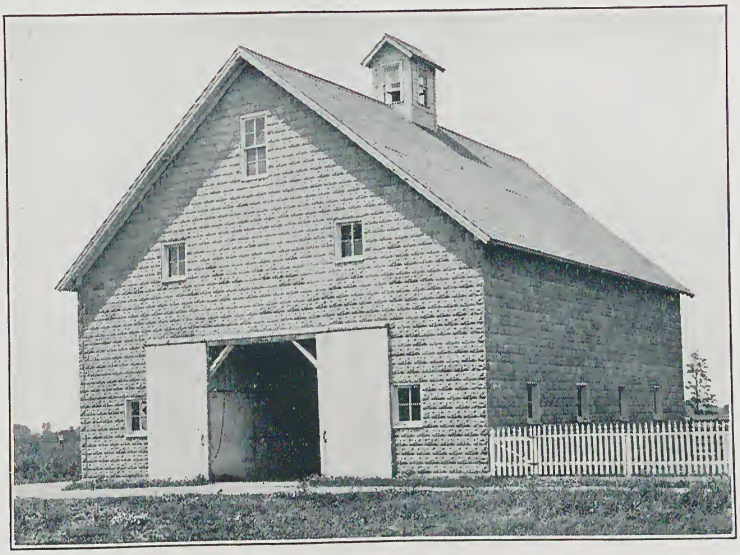


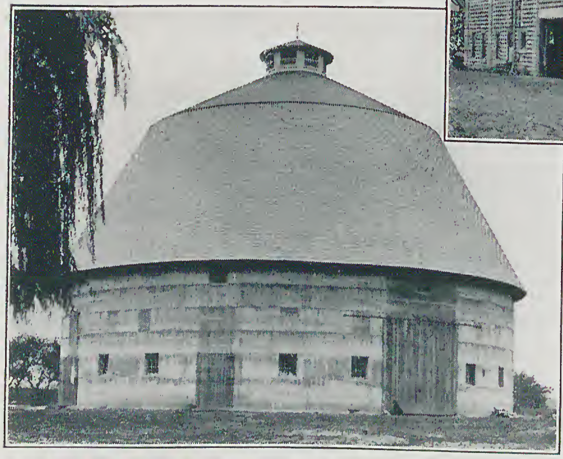
THE variety of concrete barns shown on this and the following pages makes comment on the adaptability of concrete for barn construction superfluous. The lower illustration, with the long low building and the two immense monolithic silos, is a reinforced concrete dairy barn. Details of concrete barns are found on pages 145 to 147.



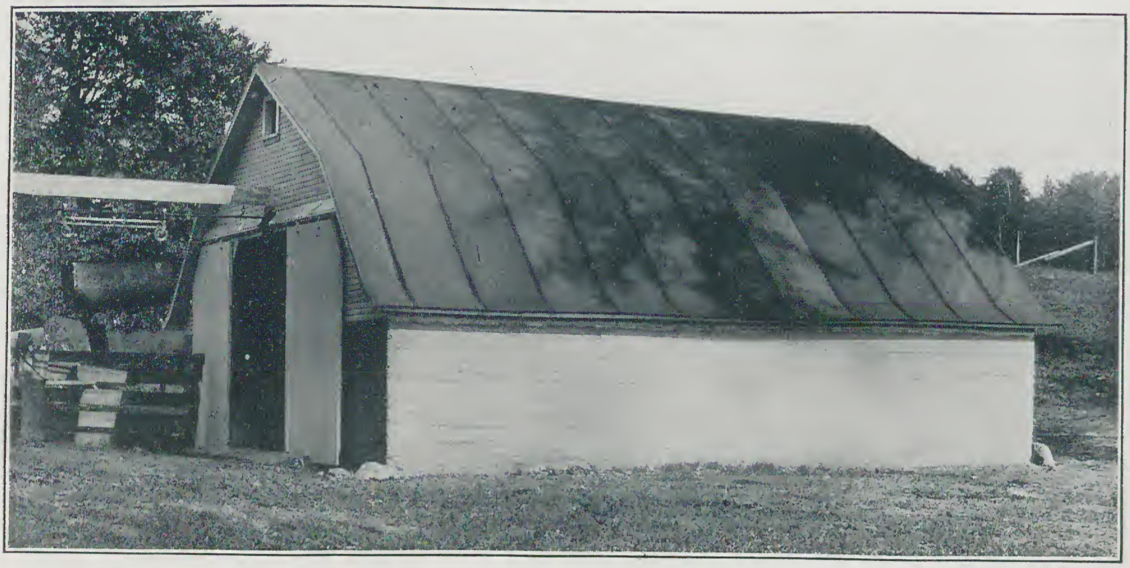



STONY POINT STOCK AND DAIRY FARM
CATTLE

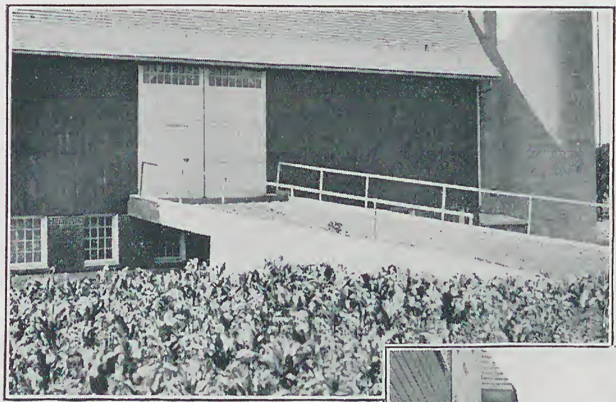




The information about concrete barns, as shown on pages 145 to 147, proves that concrete can be used for constructing barns of all types and sizes. The circular barn, whether built monolithic or of concrete block, is no longer a novelty. Suggestions for a circular barn are shown on pages 146 and 147.

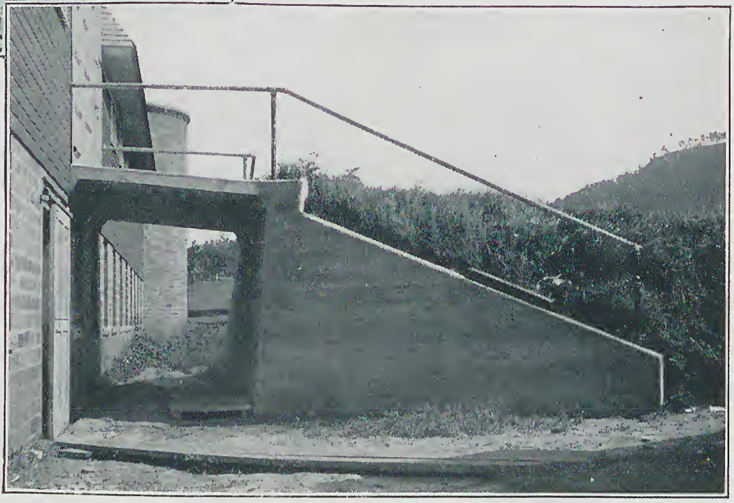


THERE is no limit to the diversified uses of concrete on the farm. Lehigh cement in construction of farm buildings and equipment has proved an investment rather than an expense.



Barn Approaches

A CONCRETE approach to the barn entrance will lighten the traction effort for teams as well as for motor vehicles. It will eliminate the bumps and strains of the makeshift approach and make possible the hauling of larger loads with less effort. Frequently the space under such approaches has been used as a storage place for fruit or vegetables or for a milk or a dairy house. Such space could also be employed for ice storage. Information in Part Two will prove helpful if advantage is to be taken of this space.

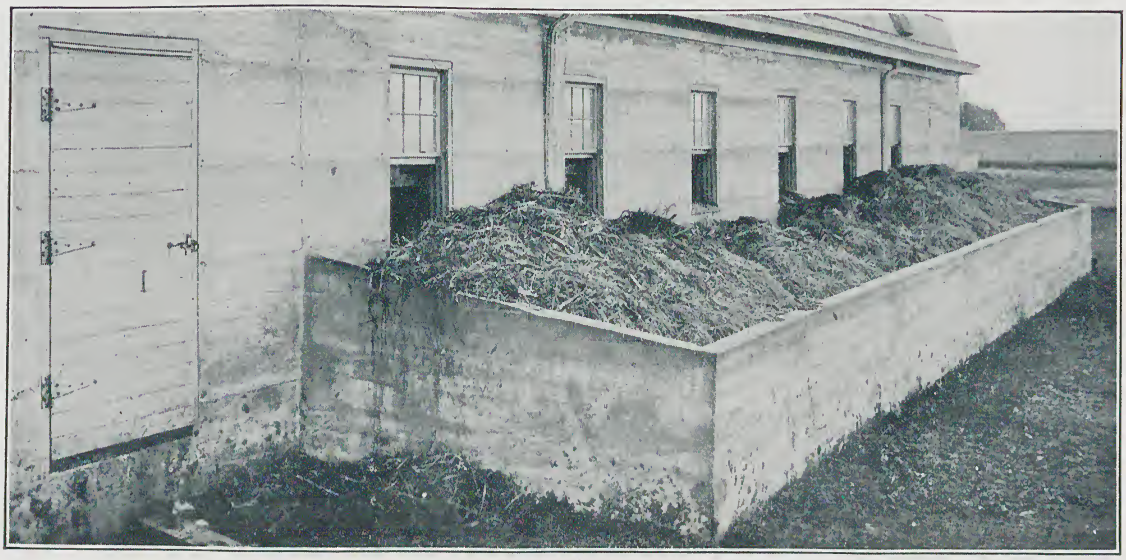


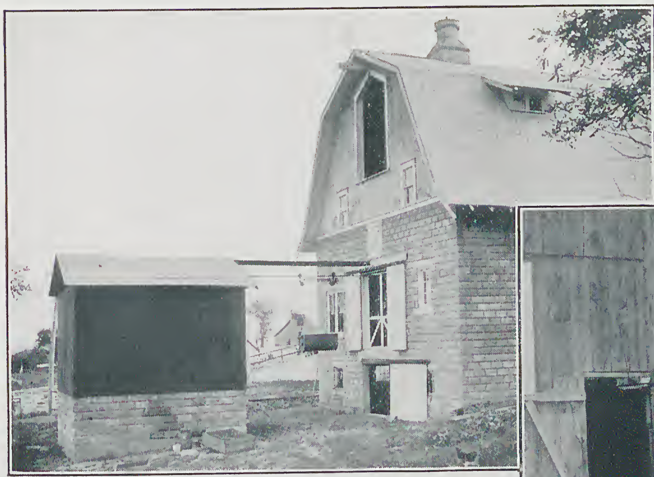
On page 70 is a practical working drawing showing the construction of a barn approach and giving information for its erection.

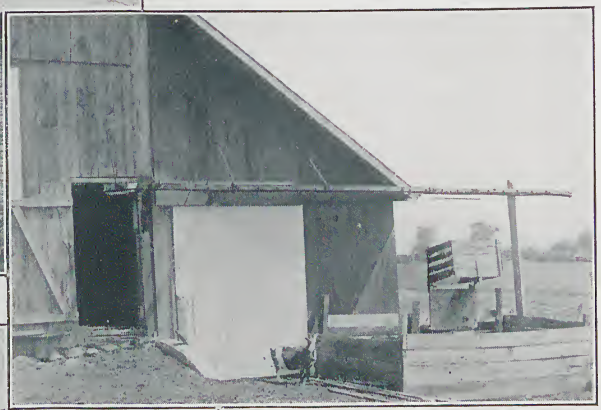
Manure Pits

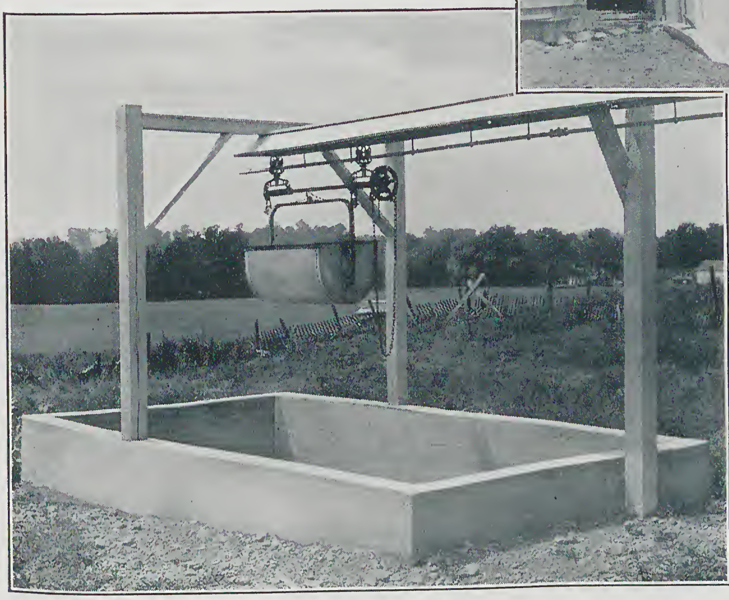
MANUFACTURED fertilizers have their place in farming, but soil fertility can be permanently maintained only by proper use of stable manure. Growing crops extract from the soil elements necessary to plant growth. Unless these elements are kept in proper balance in the soil crop yields are continually reduced.

Millions of dollars' worth of possible soil fertility are lost because of the careless way in which manure is handled on the majority of farms. The concrete manure pit is one of many concrete structures that pays for itself in a short time. Pages 74 and 75 show working details of construction.

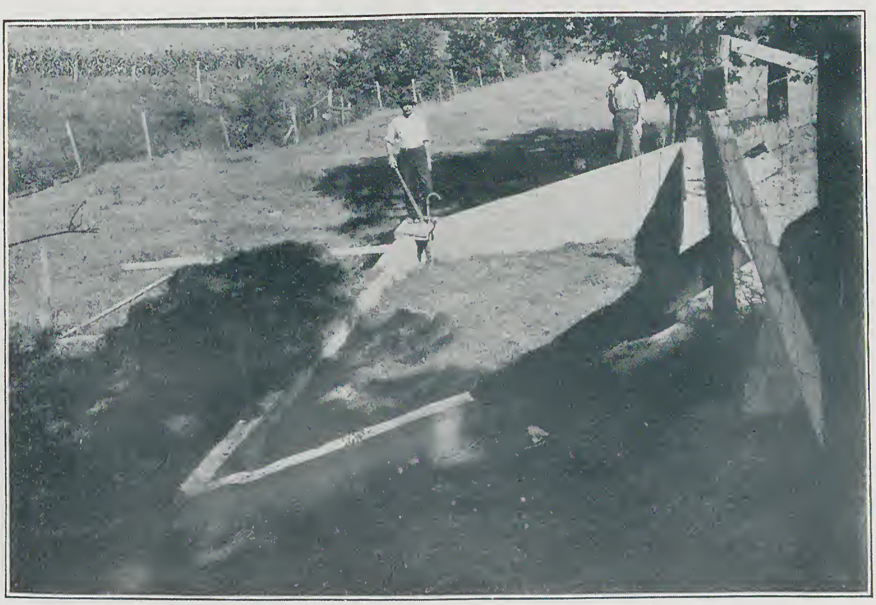


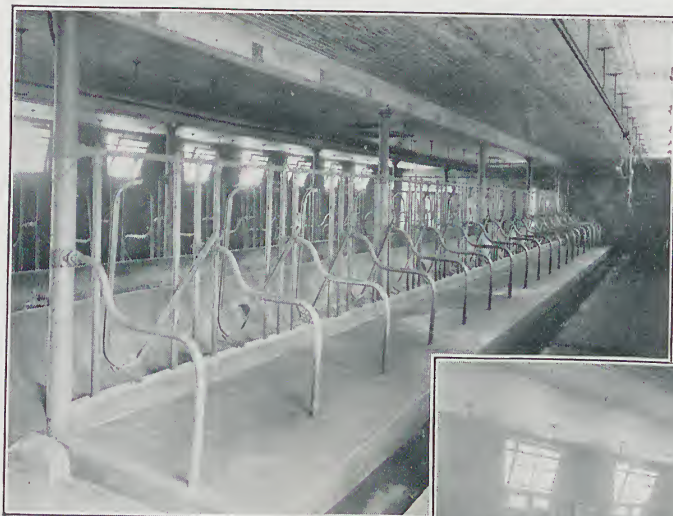






How *not* to care for stable manure is shown in the illustration directly above. This attempt at providing a manure pit is simply a waste of time and effort. The other illustrations show concrete structures of both the roofed and the open type. Either is very effective in the conservation of fertilizing elements.



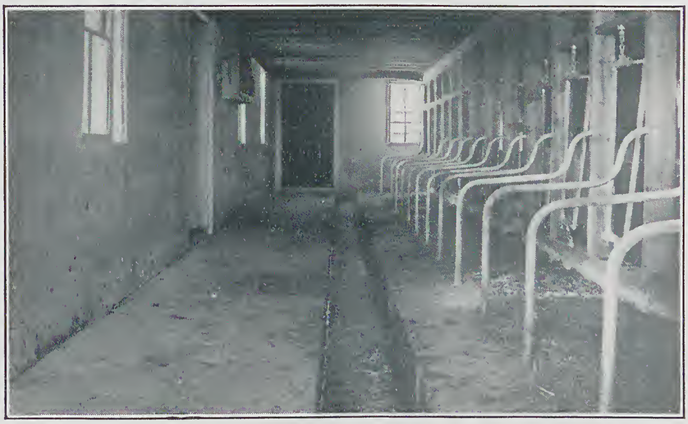


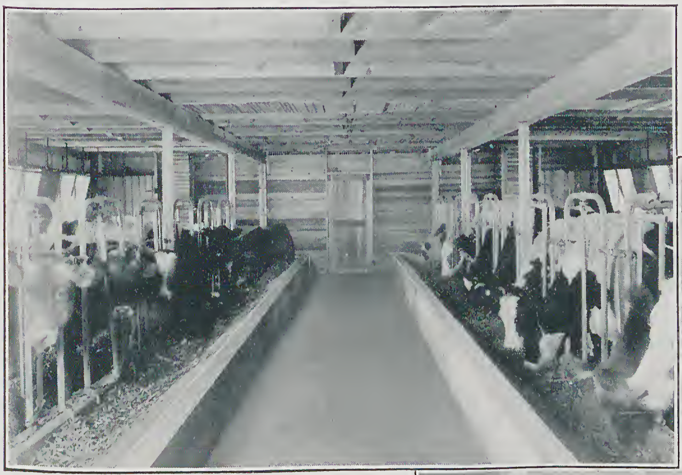
Concrete in the Barn

THE safety of your stock demands concrete housing. One of the most important parts of this class of construction is the sanitary barn floor. To prevent loss by fire, disease, and accident, no other material lends itself so readily to these requirements as does concrete.

The benefits from these floors can be augmented by the use of this same material for mangers, gutters, troughs, and grain-bins. A concrete floor for the hay-loft serves both as a fire barrier and as a protection against rats. The use of concrete for the complete construction and equipment of the barn for housing all stock is a paying investment, for not alone does it protect the stock, but it lightens the labor necessary in the proper care of the animals.

Part Two contains numerous drawings for all types of barn construction, and Part Three gives the necessary fundamental principles involved in doing this class of work.





SANITATION in the dairy barn and in other stock quarters is best secured by concrete floors, mangers, alleyways, and gutters.

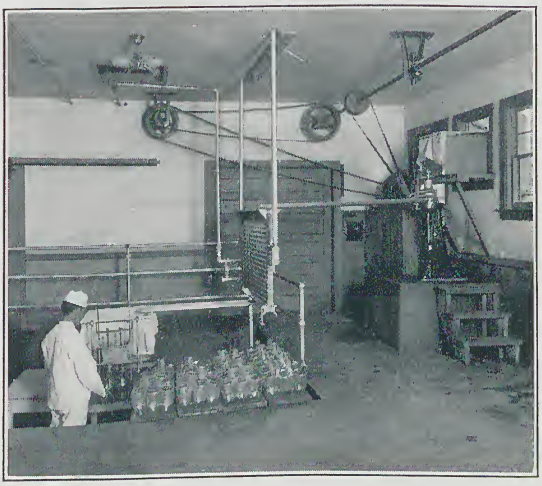
Hog Raising

PROFITS from hog raising are, to a great extent, dependent on the housing provided. Sanitation is the prime essential. Clean, healthful, sanitary quarters are absolutely necessary if the raising of hogs is to be made an asset instead of a liability.

Without warm quarters young pigs cannot be expected to develop properly. They must be in the best condition for early marketing to bring maximum profits. This can be attained only with well-ventilated, dry pens designed to provide plenty of sunlight and built so that there will be no cracks or crevices in which filth might lodge.

Concrete is the only material that will economically meet all these requirements. Further information on the advantages of sanitary quarters for hogs, with suggestions for building, is shown on pages 126 to 130.

FEEDING floors, wallows, and troughs are all sanitary and permanent when built of concrete.

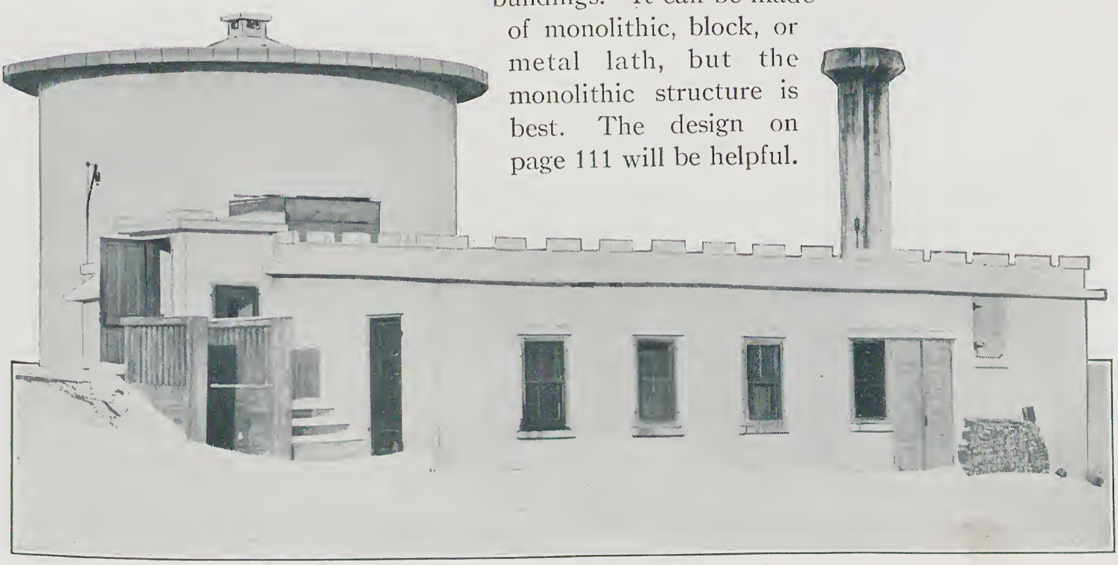


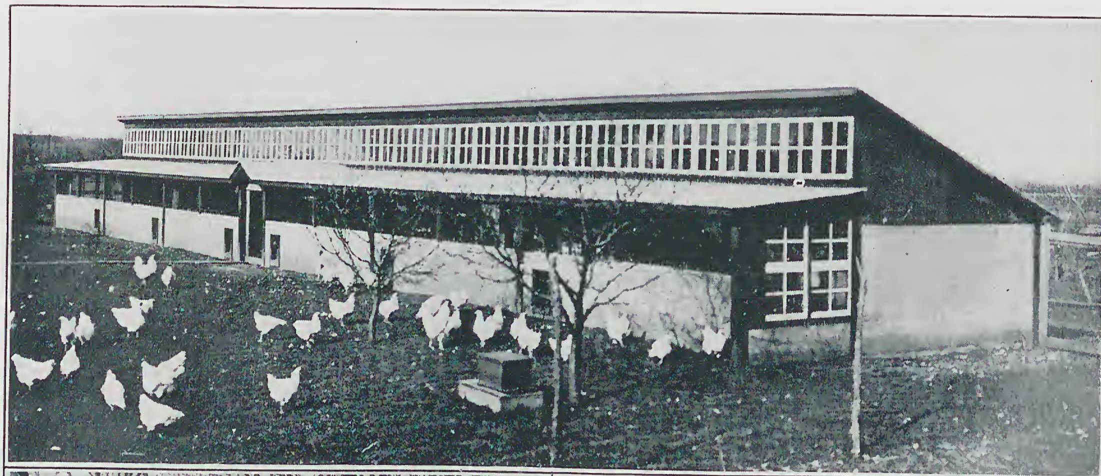
Modern Dairying

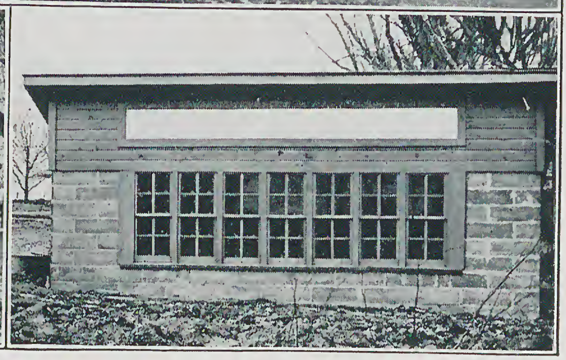
MODERN dairying demands concrete construction in all the necessary equipment, whether it be building, floors, walls, or cooling tanks. Sanitation and cleanliness in the dairy are essential. In many localities the laws provide that dairy buildings shall be built of a sanitary type of construction, and concrete is the only all-purpose material which will enable the dairyman to meet these requirements. Besides its cleanliness, concrete will withstand the moisture typical of the average dairyhouse. See pages 108 to 111.

Ice Houses

EVERY farm should have an ice house to prevent undue waste of perishable products. Ice costs little beyond the labor of harvesting. The convenience of having a supply available for the care of farm products as well as for the home is an economy. This storage house should be located where it can be well drained by underground tile, and where it will be shaded in midday by the trees or larger buildings. It can be made of monolithic, block, or metal lath, but the monolithic structure is best. The design on page 111 will be helpful.



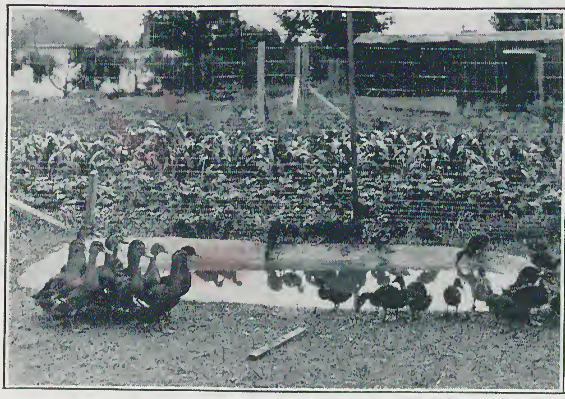


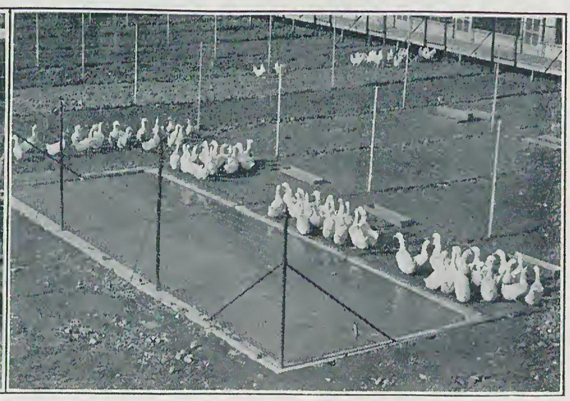


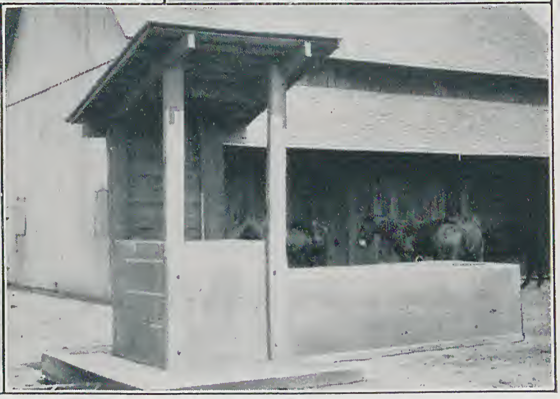
Poultry Houses

POULTRY kept in properly designed concrete houses have plenty of sun and air and are safe against attack from rats and other marauding animals. Such houses are more easily kept free from lice. They are sanitary and easily cleaned. An ideal poultry house is illustrated on page 122, which also shows details and gives building instructions.

Duck raising does not require flowing streams—in fact, but limited water exercise is advisable if the young birds are to reach marketable condition at early age. All the facilities needed can be provided by a concrete pool which can be built near the poultry house. Information as to the building of concrete pools is found on page 100.

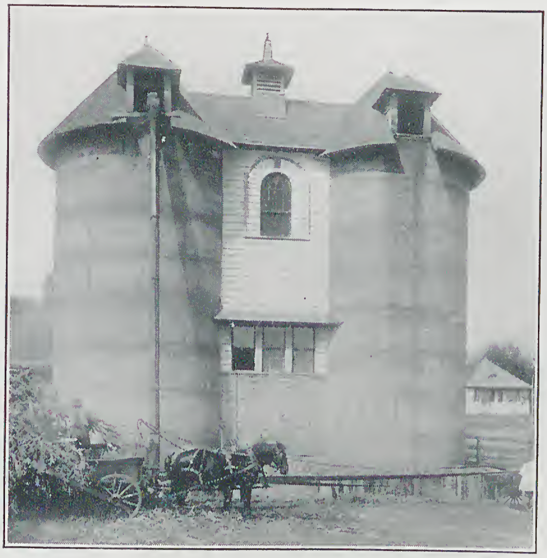






Watering Troughs

THE inconvenience of the old wooden trough has been done away with by the use of concrete. The importance of the watering trough and the simplicity with which it can be built make it one of the first pieces of concrete work done on the farm. To avoid the unsanitary mud hole adjacent to your trough a small section of paving, as shown on page 95, is advisable.

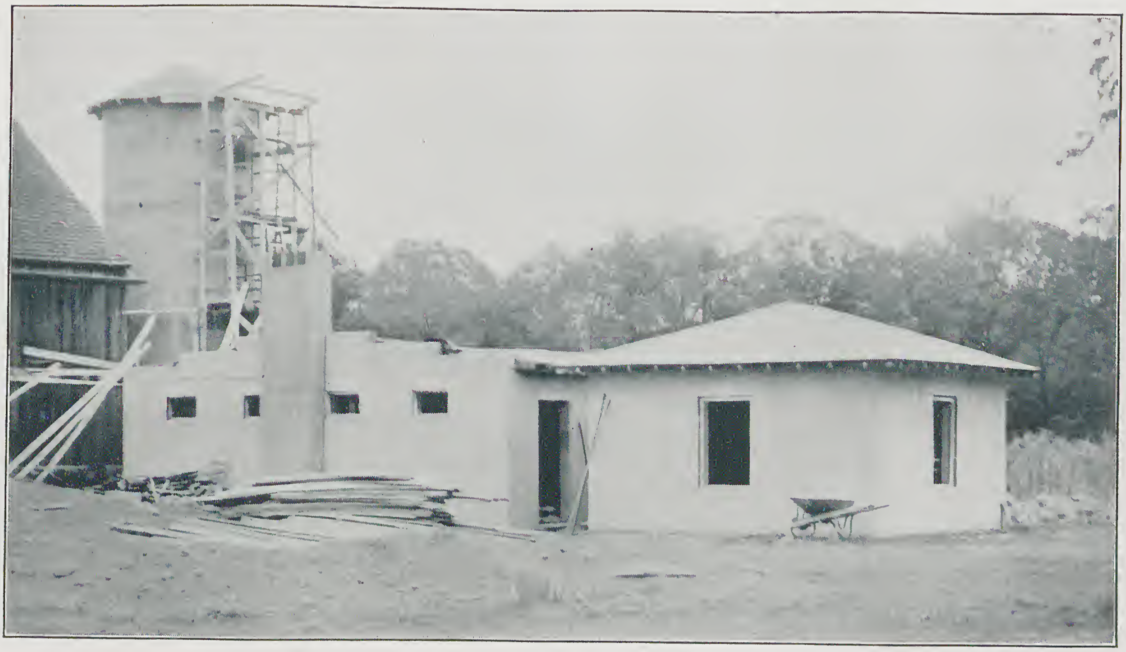


Concrete Silos

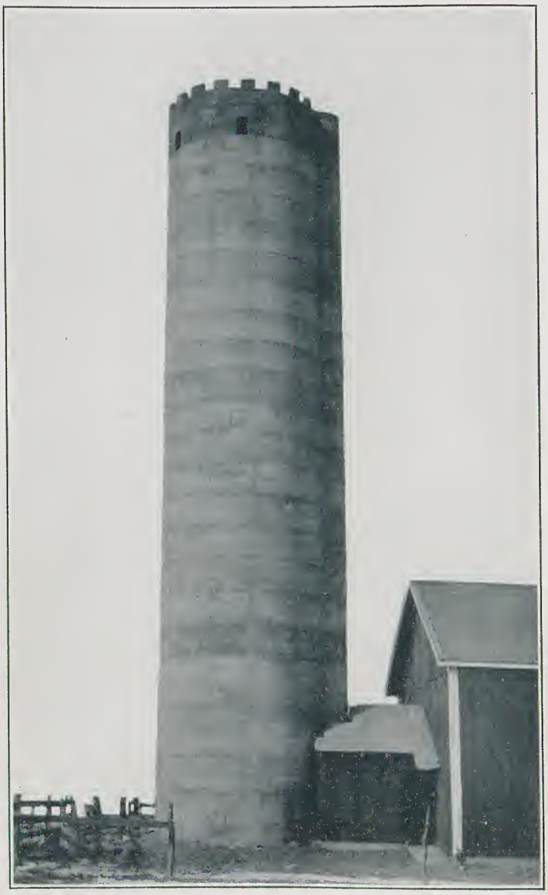
WHEN farmers gradually awoke to the advantages of feeding silage, and the silo as a permanent farm structure sprang into evidence here and there, it was characteristic to refer to these very profitable structures as "pillars of progress." It was dairymen in general who first recognized the silo's profit-earning capacity, and for a long time a silo was the mark of a dairy farm. However, it has long since been learned that stock other than dairy cattle can profitably be fed silage. Any and every farm where only a small herd of animals is kept for domestic convenience can hardly afford to be without a silo because it is the only structure that makes green pasturage possible twelve months in the year.

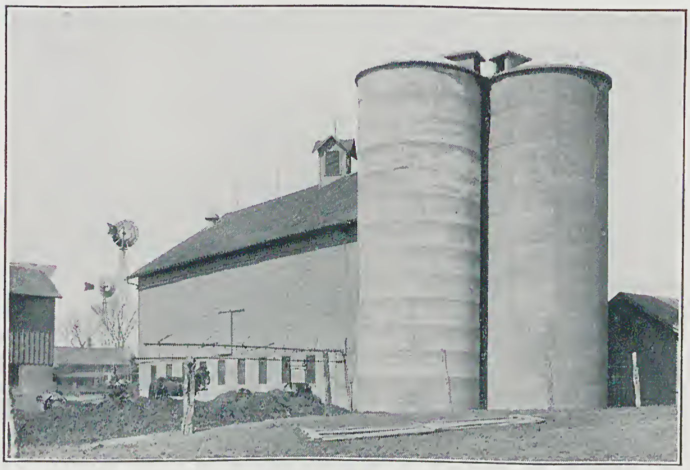
When building a silo, the number of years of service should be taken into consideration. A concrete silo is permanent, fireproof, windproof, and rot-proof, eliminating repairs and upkeep.

Concrete silos may be built monolithic, block, or stave. They have been referred to on pages 136 to 144, where tables, detailed drawings, construction principles, and other necessary information will be found.

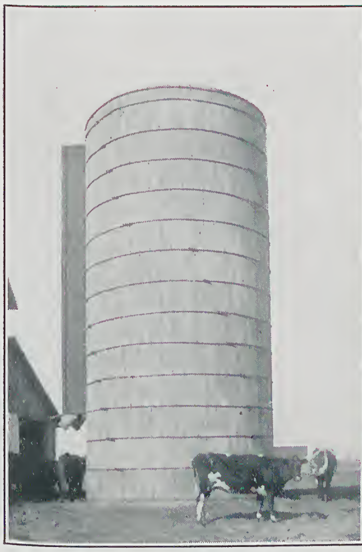
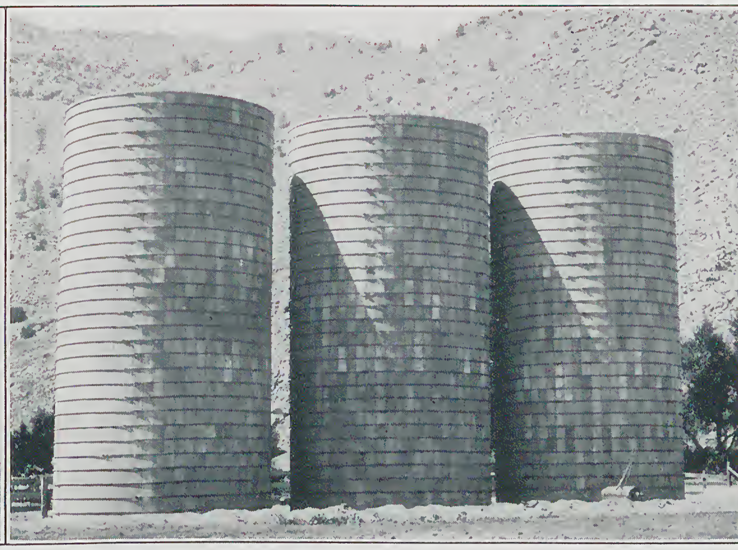
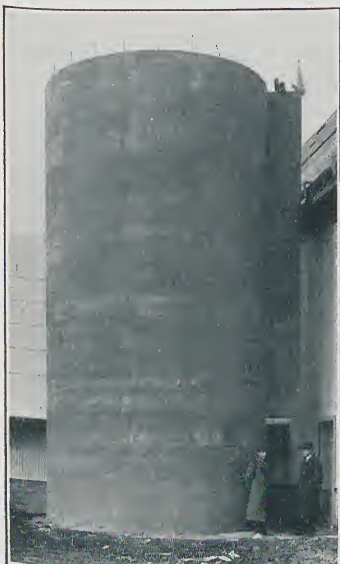


THE structure above serves both as a silo and as an implement storage house. The lower right-hand picture shows one of the largest silos in existence.

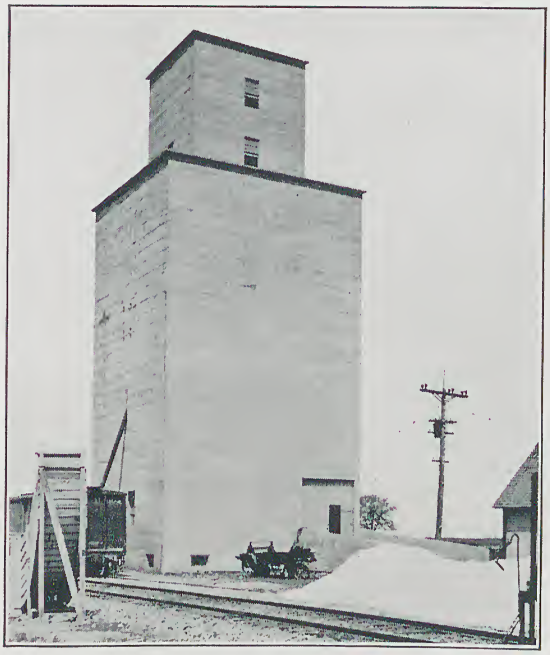




One of the most desirable advantages of a concrete silo is its ability to withstand windstorms and fire, as evidenced in the lower illustration. The diameter and height of the silo depend upon the requirements. Complete information is found on pages 136 to 144.





Bins and Elevators

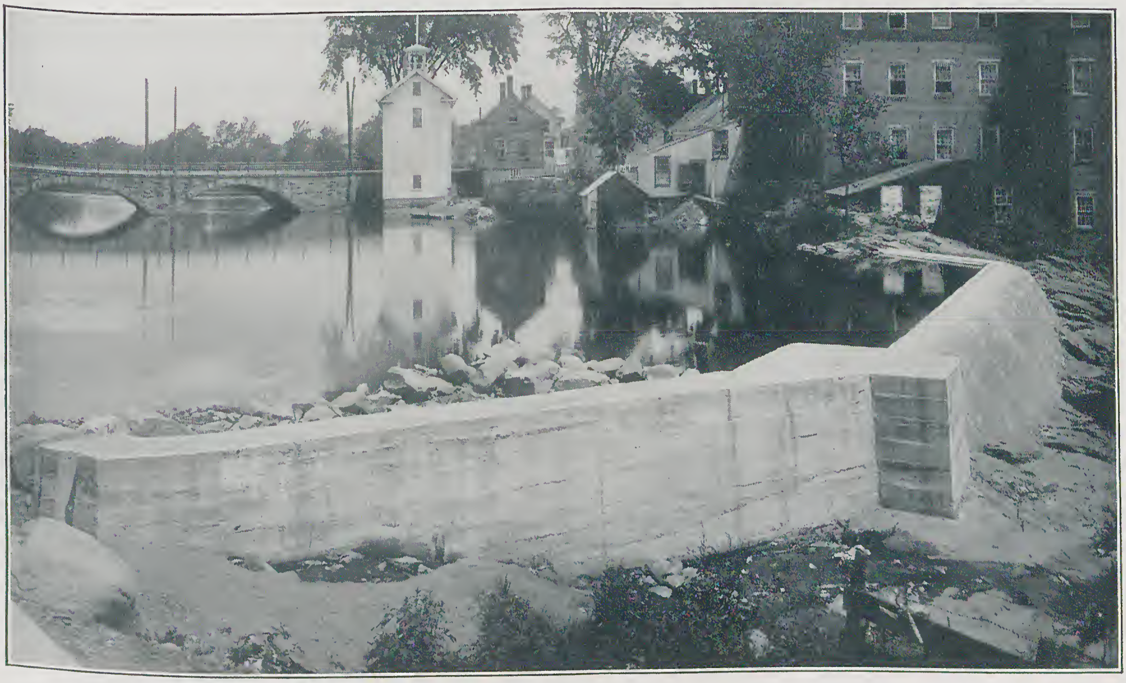
FIRE-PROOF and rat-proof bins, tanks, and grain elevators built of concrete have proved practical. Monolithic construction is the greatest obstacle to the breeding of insects and destructive rodents, and loss by such pests can best be averted by concrete construction. Stores of grain and other materials may be guarded against the ravages of fire with this artificial stone, which, by its watertightness, also protects against rot and dampness. Strength, permanence, adaptability to almost any design, cleanliness, lack of maintenance—all point to concrete as the ideal material with which to build.

Concrete Dams

SMALL streams running through your property can be profitably dammed either to supply motive power or as a water storage. Stationary farm machinery can be economically operated by water power, thus conserving what was formerly a decided waste. For either an auxiliary or a regular water supply a dam will soon pay for itself.

Concrete is recognized as the best material with which to construct a dam. It serves as well for such adjuncts as piers, boat-landings, and platforms for swimming and ice handling.

Construction of a dam entails engineering problems, and it should be attempted only by a man experienced in this class of work.



Highway Construction

PROSPERITY follows in the wake of paved highways. They not only provide an outlet for the goods you produce, but afford greater merchandising possibilities.

Instead of allowing the conditions of the highways to indicate the time for marketing your products, why not dispose of them when prices are at a maximum? This can be done only over roads that are traversable 365 days in the year.

Small loads must be carried at a much slower rate of speed over muddy byways, and the wear and tear on your hauling equipment is multiplied many times. Replace roads such as those pictured at the top of these pages with hard-surfaced feeders, shown at the bot-

tom of these pages, to and from the point of sale and your source of supply.

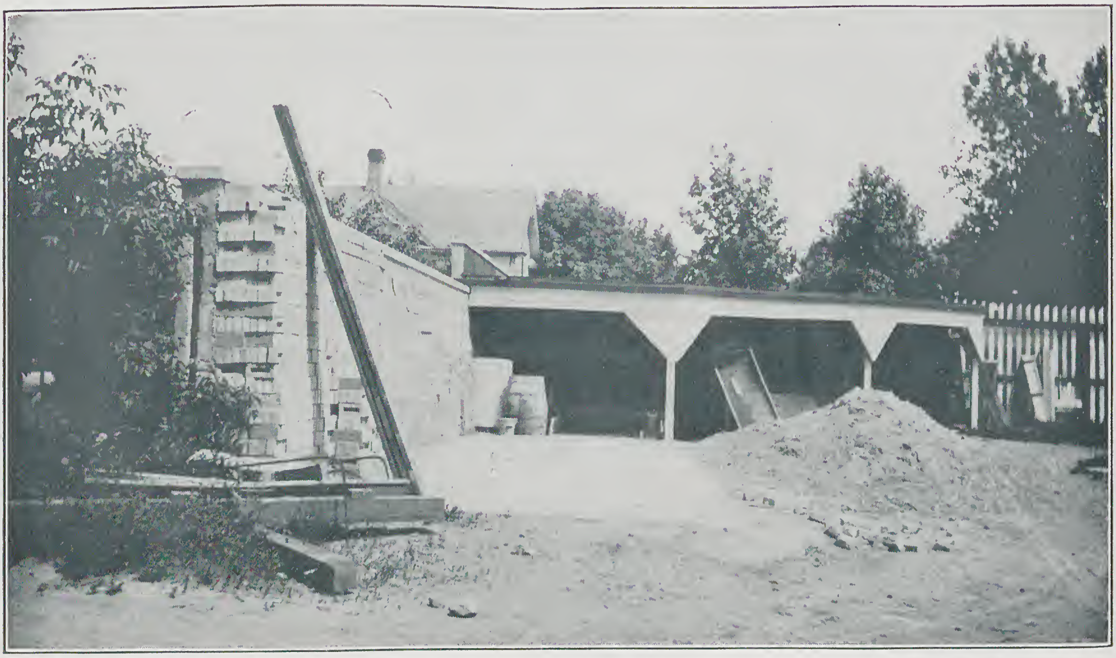
Permanent, year-round roads bring your neighbors near, lessen the distance to church and school, and tend to improve your home life and conditions. We cannot all be located directly on the line of a railroad, but we can bring transportation facilities to our door in the most economical way by constructing highways of concrete.

As a highway building material, concrete has proved its superiority in that it gives us, at a moderate first cost, a permanent road requiring a minimum of maintenance. Actual test has proved that it has the greatest tractive value, and the fact that it can be built with the lowest possible crown makes it ideal for horse-drawn as well as for motor vehicles.

Information regarding the construction of highways is found on pages 132 to 135.

Industrial Driveways

CONCRETE driveways in building material or other commercial yards make hauling problems easier. Many yards have paved areas on which such materials as shingles and lath are piled in order to keep them away from all contact with the soil and thus prevent rot. Other yards have found the paved area, with shed adjoining, a convenient working platform for the manufacture of various concrete products during spare time. This type of construction is explained on pages 64 to 68, under the heading "Floors, Walks, and Pavements." Complete information about "Concrete Products" is found on pages 76 to 92.

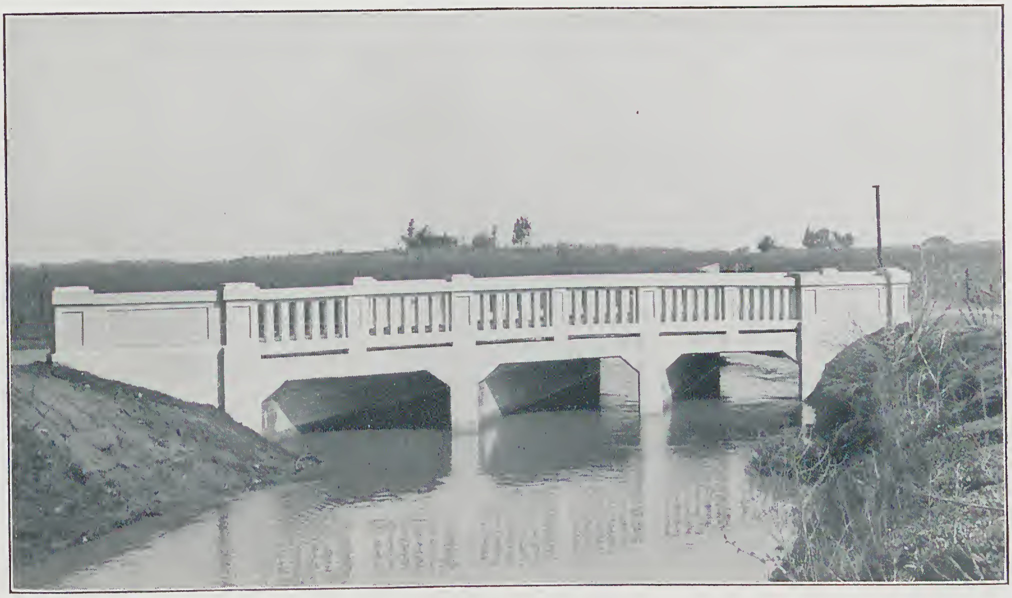


RAPID delivery of orders is insured by concrete pavements, whether highways or driveways. The lumber-yard, the coal-yard, the building material dealer's yard, the post-office, and other similar industries are all dependent upon concrete roadway for efficiency in delivery and cleanliness of surroundings.

Irrigation Canals

MILLIONS of acres of arid lands have yielded their fertility through irrigation, and irrigation has been made to produce the greatest possible returns through the use of concrete. Concrete pipe plays a large part in many irrigation projects conducting water for some distance in pipe lines.

Water is frequently carried over ravines by means of concrete flumes, which are really bridges supporting the sluiceway in which the water travels. Concrete is used in canals by essentially paving their bottom and the slopes. As canals and flumes are generally used in large projects, plans and specifications should be prepared by an engineer or a contractor who specializes in irrigation problems. However, for small canals, the specifications under "Floors, Walks, and Pavements," pages 64 to 68; "Troughs, Tanks, and Bins," pages 93 to 96, will answer.

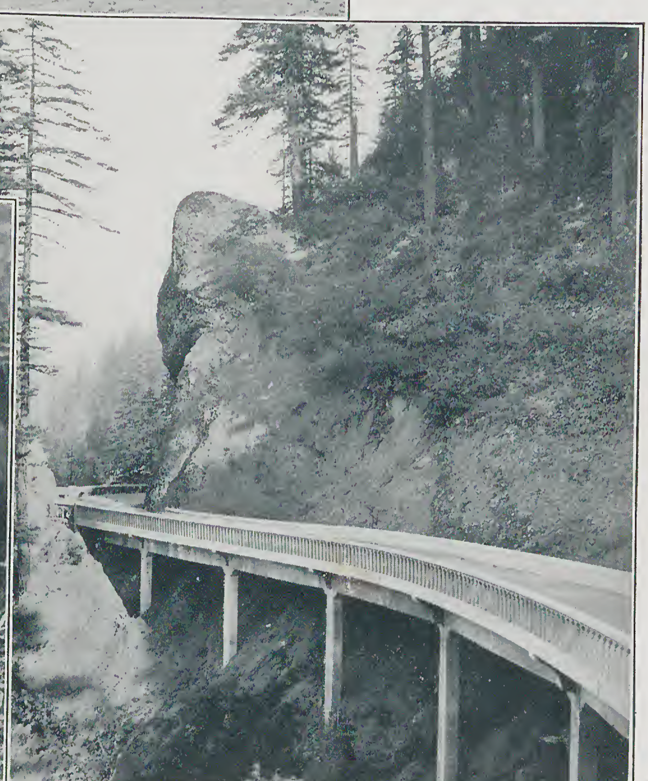


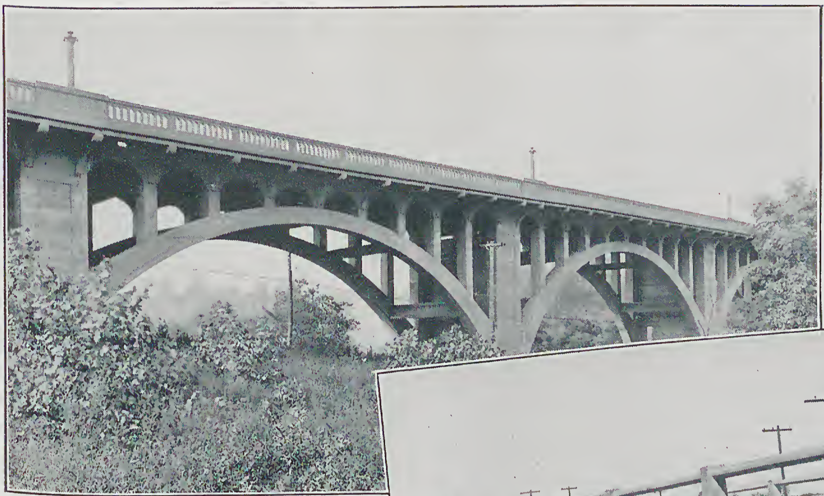
Culverts and Bridges

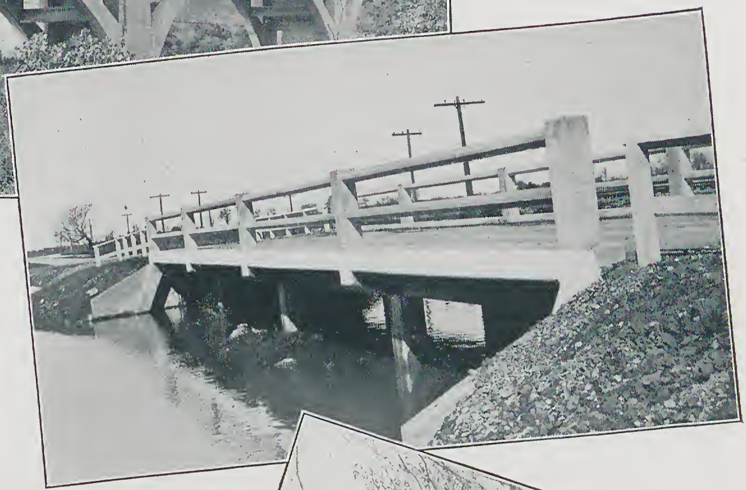
CULVERTS or bridges must be provided in highways to pass natural flow of streams as well as to care for excessive flow during flood periods. Concrete bridges and culverts have almost entirely replaced all other types, particularly for small and moderate spans, and the use of concrete is rapidly being extended for long spans which but a few years ago would have been deemed impractical to construct of concrete.

A culvert is generally regarded as an opening too small to be classed as a bridge. Although there is no definite line to distinguish between the two, it is common to refer to openings 10 or 12 feet or more in span as bridges. The construction of a bridge involves engineering principles, and as there are many factors, including a careful survey of existing conditions, that enter into its design, the services of an experienced bridge engineer is advised. Except in very unusual cases, the average contractor can design and construct a box culvert. Drawings are shown on page 151.

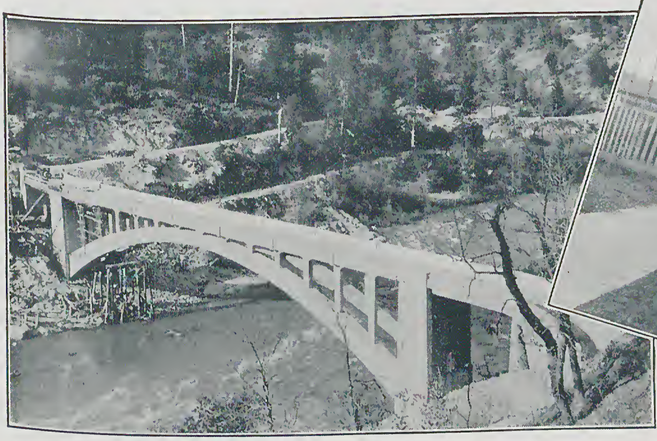
BRIDGES and culverts demand the best concrete. Good materials are as essential as good workmanship. Specify and use Lehigh—the National Cement—the quality of which is unsurpassed.

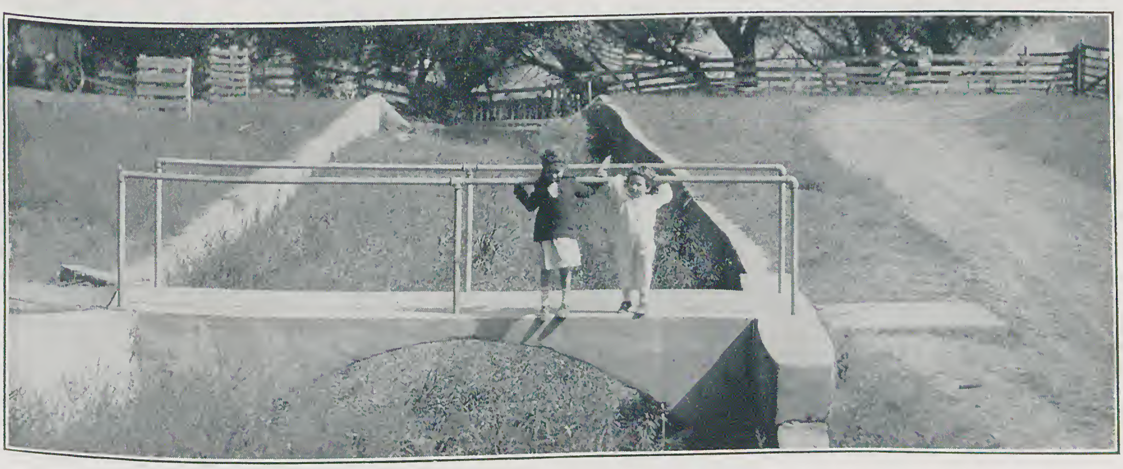


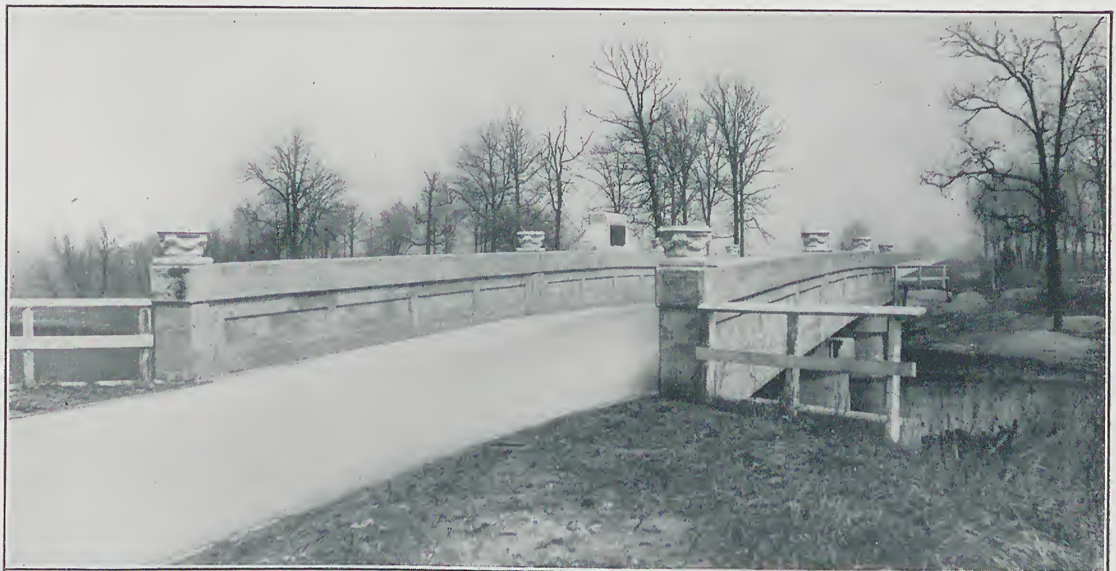


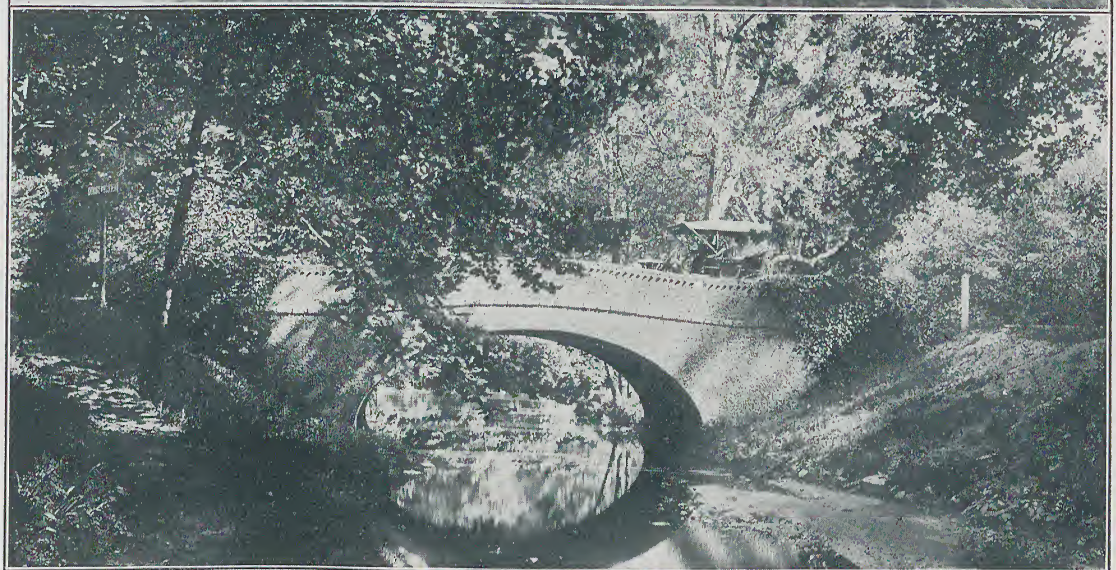


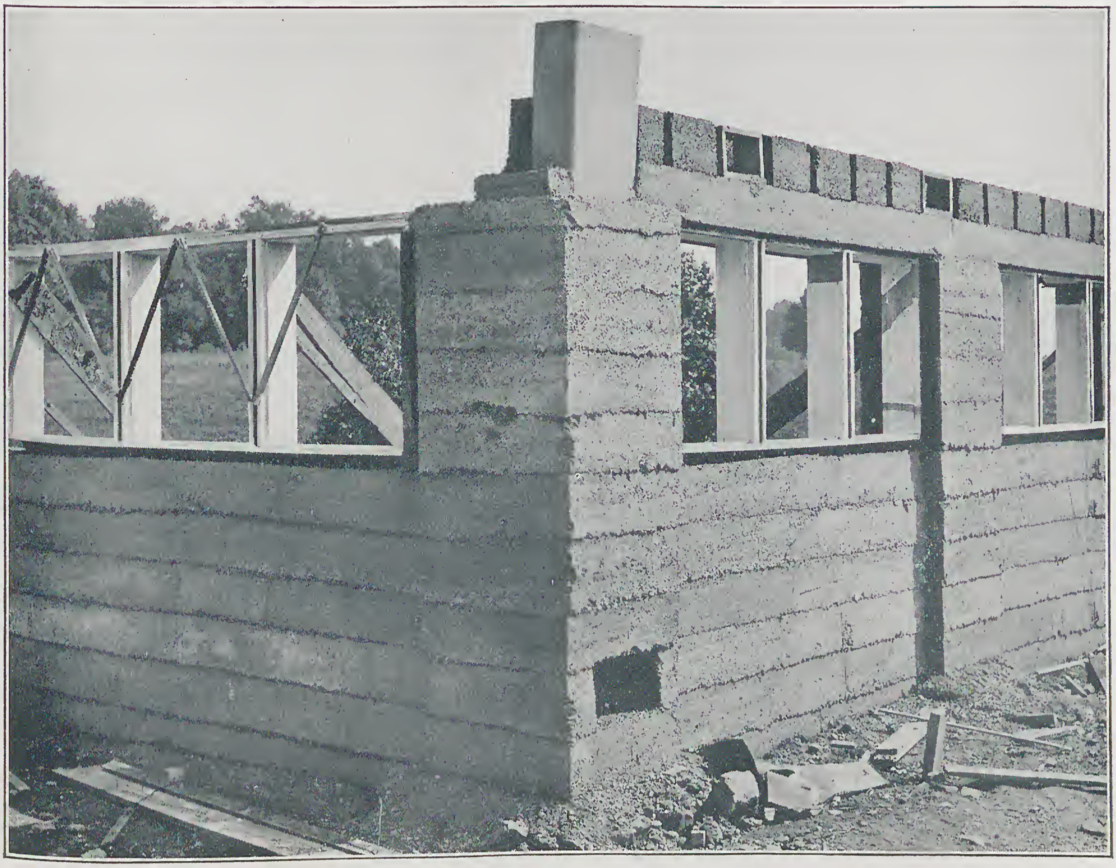
Concrete has practically replaced all other materials in culvert and bridge construction. Types of bridges, from the simplest box and pipe culverts to the more pretentious ones, are illustrated.











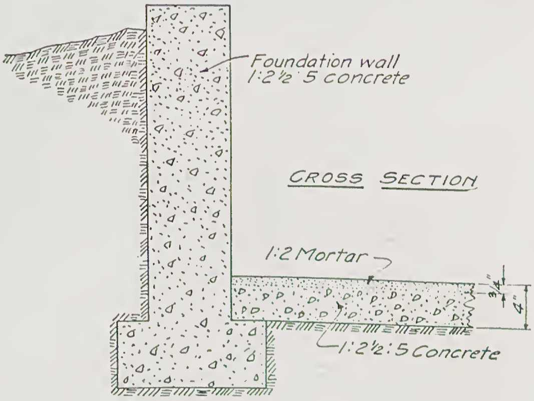
No building can endure without proper foundations and walls

Foundations and Walls

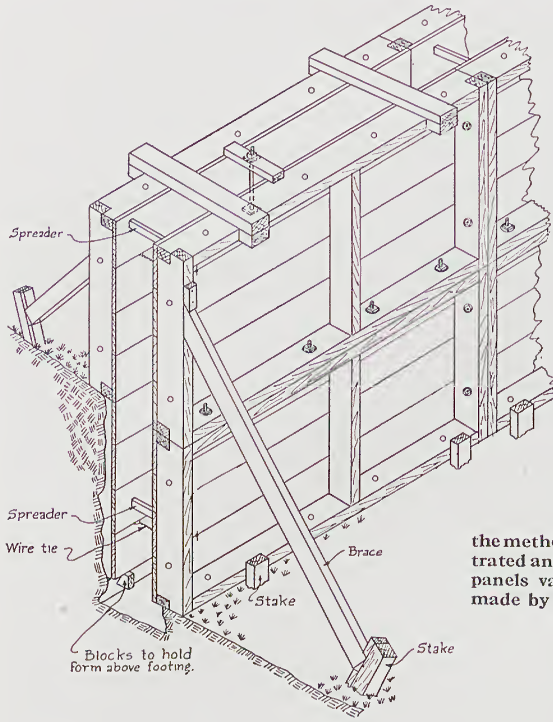
WHEN the simple principles of concrete practice outlined under "Fundamental Principles," pages 153 to 185, have been observed, building a concrete foundation is one of the easiest types of construction work and within the range of any one's ability.

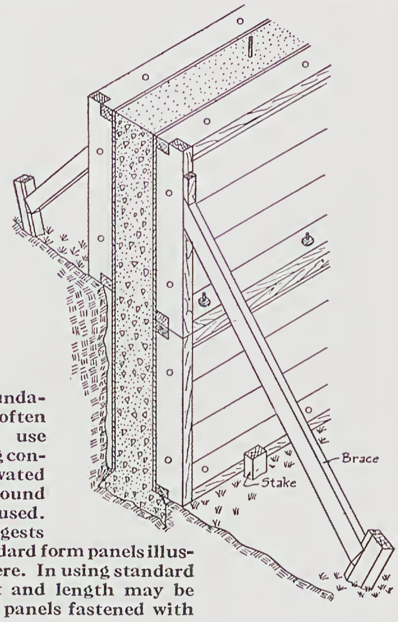
Where soil conditions lack the best supporting capacity, the foundation wall proper is usually built on a footing, which is a wider section of concrete, varying in thickness to meet conditions, laid in the bottom of the foundation trench and on which the wall proper is started. After good bearing area is secured through spreading out a footing, say ten or twelve inches wide and six or eight inches thick, the foundation wall proper may be only six inches thick if a small building is to be carried.

Dimensions of footings must be varied in accordance with the bearing capacity of the soil. It is not possible to give uniform width for footings, but it is an easy matter to make tests of the soil and from these determine the dimensions required. The average barn has walls from eight to ten inches thick, and may require a footing two feet wide and twelve inches thick to support the load of the structure. For a two-story house having eight-inch walls soil conditions may require a footing 18 inches wide and 12 inches thick. If it is not convenient to determine the actual bearing capacity of the soil, common practice requires

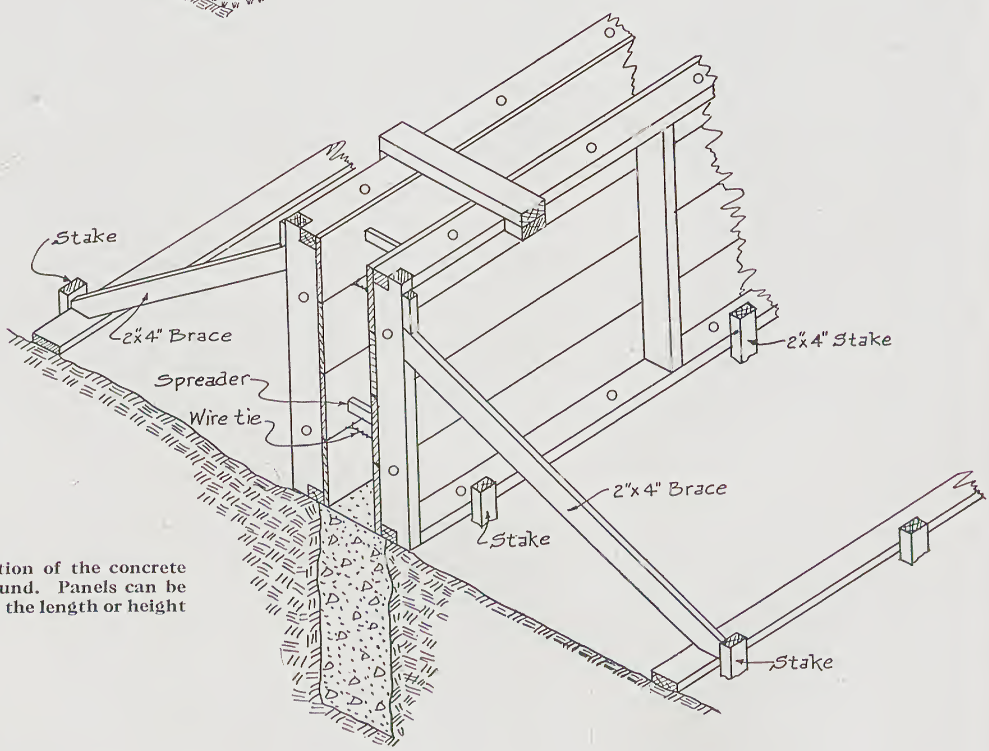


Concrete basement foundation wall





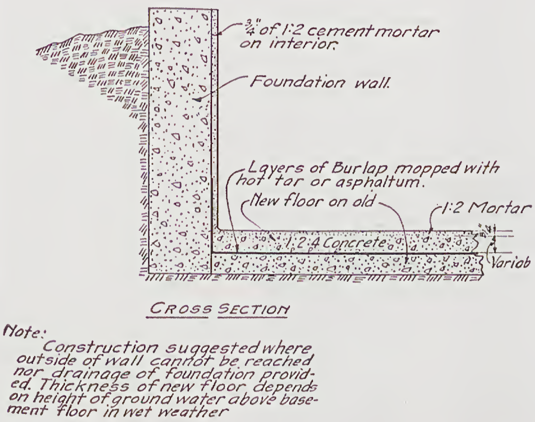
For simple foundation work it is often unnecessary to use forms for placing concrete in the excavated trench. Above ground forms must be used. This sketch suggests the method of adapting standard form panels illustrated and described elsewhere. In using standard panels variations in height and length may be made by assembling added panels fastened with bolts

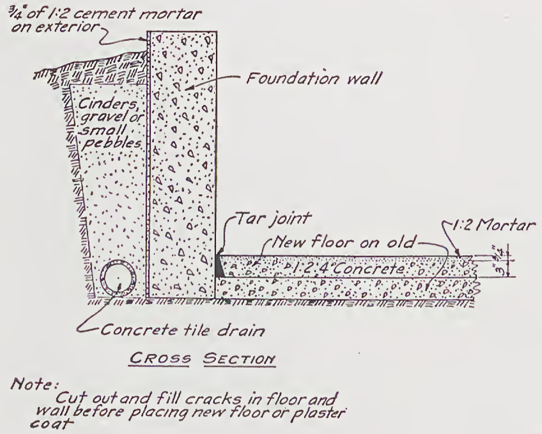


Forms for portion of the concrete wall above ground. Panels can be added either to the length or height

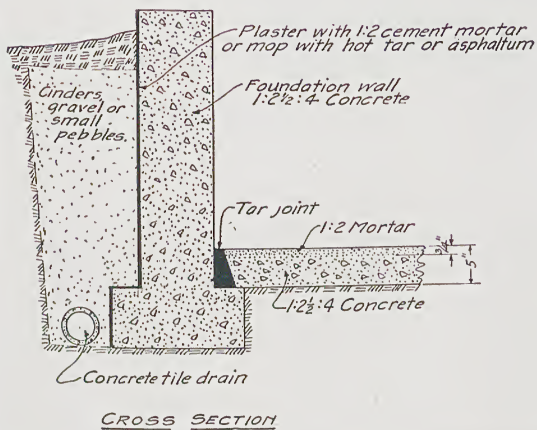
footing just to be on the safe side. See table on page 181, which shows bearing power of soils in tons per square foot.

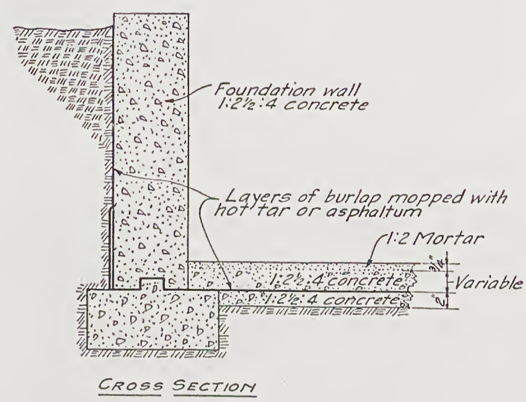
Thickness of foundation walls, like thickness of foundations, depends upon the load to be carried. Ordinary building walls necessary for such structures as poultry houses, garages, houses, and barns, range in thickness from six inches for small buildings to ten or twelve inches for larger ones. Foundation walls for ordinary buildings without a basement or a cellar need not be made of a very rich mixture. Absolute watertightness is not necessary. Therefore, a 1 : 2½ : 5 or 1 : 3 : 6 mixture or even leaner may be used. For watertight wall construction a 1 : 2 : 4, 1 : 2½ : 4, or in





Repairing existing concrete to prevent seepage of ground water. Care must be taken to carry a continuous line of waterproof material over the floor space and high enough on the walls to provide against maximum water pressure





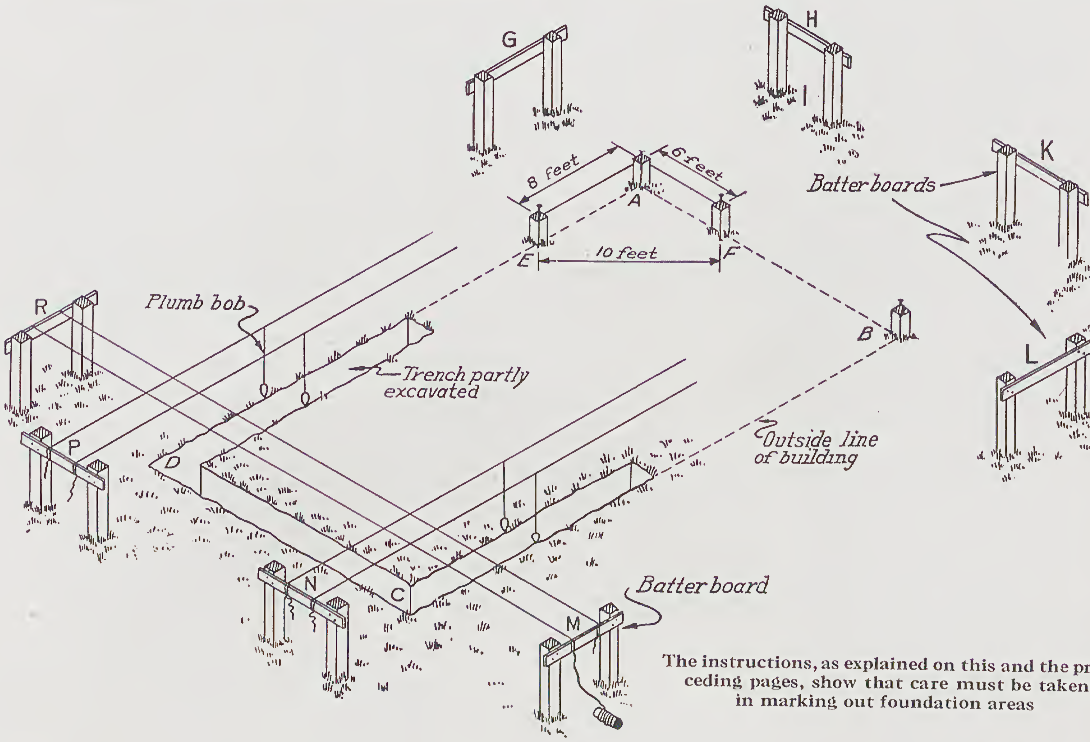
Foundations and basements built in low ground should be constructed to provide against maximum water pressure. The application of waterproofing materials will not remedy faulty concrete work. The concrete itself should be rich enough to be impervious to moisture

extreme cases, where much ground water is to be encountered, a 1:2:3 concrete, should be used for the foundation walls of buildings having basements or cellars. See plans on following page, which show methods of waterproofing foundation walls.

It is common practice to play safe by reinforcing walls with a small amount of ⅜-inch round steel rods placed at the wall center and spaced about two or two and one-half feet, center to center, vertically and horizontally. If walls are between eight and ten inches thick, two such sets of reinforcing are sometimes used, one set being placed two inches from the exterior face of the wall and the other the same distance from the interior face. Window and door openings have corners where cracking may occur, due principally to temperature changes. Such openings are usually framed with rods parallel to the sides and diagonal with each corner. In a case of concrete lintels such units are properly reinforced when precast, or as cast in place.

In excavating for foundations the trench should be carried deep enough so that its bottom will extend below possible frost penetration to firm bearing soil. Otherwise upheaval due to expansion of the soil when freezing may cause cracking of the foundation which will probably extend up into the structure wall.

To mark out a foundation area a stake is set at the location of one corner of the building. From this stake a string is stretched to another stake set in position corresponding to the other corner on the same side of the building. From this second stake a string is stretched to a third stake that is set at a point corresponding to the length of this side of the



The instructions, as explained on this and the preceding pages, show that care must be taken in marking out foundation areas

building. Before setting the third stake, however, it is necessary to square up the corner at the location of the second stake if the building is on a right angle. This is done by measuring off a distance of eight feet from the center of the second stake driven back toward the first stake, and setting a pin in the string at this eight-foot point. Then a distance of six feet is measured from the center of the second stake along the string leading to the third stake, and this six-foot point marked in the same manner. The person holding the third stake then moves it back or forth to the right or left as may be necessary, keeping the string tight meanwhile until the diagonal distance between the two pins is exactly ten feet, as determined by an assistant measuring with a ten-foot measure. The third stake should be driven firmly in place when this ten-foot distance has been accurately fixed. The corner marked by the third stake can be squared in the same manner, and so on until all four corners of the building have been located.

One of the illustrations shown in the section on Forms on pages 163 to 167 calls attention to the fact that only single form sections may be required in some foundation work, where the natural soil is firm enough to be self supporting. This, of course, applies only to the concrete work below and up to ground level. From that point upward forms must be provided on both sides of the concrete. In soils that are not naturally well drained it is sometimes necessary to lay a tile drain at the bottom of the foundation trench and just outside the foundation wall or footing leading to some natural outlet or drainage bed; otherwise a house cellar, for example, might be damp at certain seasons of the year, owing to water leaking into the cellar through a neglected construction joint in the wall, or because the joint between foundation wall and concrete floor was not properly sealed. See illustrations on page 59.

Monolithic concrete walls above ground are usually made of a 1 : 2 : 4 or a 1 : 2½ : 4 concrete. Field stones, ranging in size up to four, five, or perhaps six inches in diameter, may be used to advantage in ordinary concrete foundations. By ordinary foundations is meant those which are not intended to enclose a basement or cellar, but merely to support the structure. The use of such stones in proper ratio to the concrete mixture itself results in considerable economy. Such stones are frequently referred to as rubble stones or nigger-heads. If used as just indicated, the following precautions must be observed:

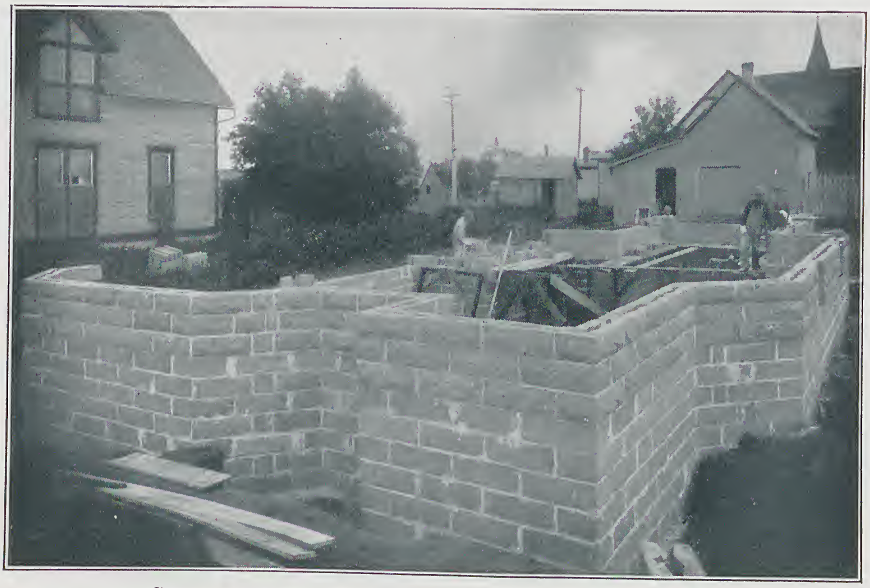
Sturdy forms maintain correct lines

The stones must be clean and free from all adhering material, such as loam, clay, and moss. They should be wet immediately before being placed in the trench with the concrete, and no stone of this kind used should be larger in greatest dimension than one-third the thickness of the foundation wall or other section in which it is used. In placing such stones they should not be dumped into the trench promiscuously with the concrete, but rather distributed uniformly by hand so that they will lie at least two inches back from the face of the wall and no nearer to each other in the wall than will permit surrounding them completely with the concrete mixture.

Concrete block is being used more extensively in all kinds of foundation work, particularly for small and medium sized structures. Usually an ordinary concrete footing is laid first and the block masonry wall started upon this. When using concrete block, the principal precaution to take is to be sure that they are well and uniformly bedded in a rich Lehigh cement mortar, not leaner than 1:2½ or 1:3, and that all joints are well filled and pointed up. If this is not done, spots will occur where leakage will give trouble. As an added precaution, block foundation walls are usually given a quarter-inch coat of rich sand-cement mortar on the exterior before the foundation trench is back filled. The proper mortar proportions for coating and pointing will be found on page 158.

Block walls for ordinary square or rectangular buildings need no reinforcement. Precast window-sills and lintels are usually reinforced.

Concrete is used very extensively for walls to enclose private grounds, commercial plants, barnyards, to help hold embankment fills and terraces in place, and to form the principal structural part of a reservoir, swimming pool, or similar structure. No matter what the type of wall, and regardless of whether the construction is monolithic or block, the adaptability of concrete permits a wide variety in surface appearance. Where concrete walls are used simply as enclosures, as for a barnyard, they require but little strength beyond that necessary to make them self supporting. Under such conditions walls are often built of large precast units or slabs. These slabs may either be cast in place or be built elsewhere so that they will fit into recesses in the sides of posts or pilasters previously set. The advantage of precasting slabs for such a wall is the ease of assembling the units. These walls have a panel and pilaster effect, the posts being the pilasters and the slabs the panels. The same applies to walls, which may be built of concrete silo staves, although these are not so attractive as the other type because of the greater number of pilasters and panels and the smaller units.



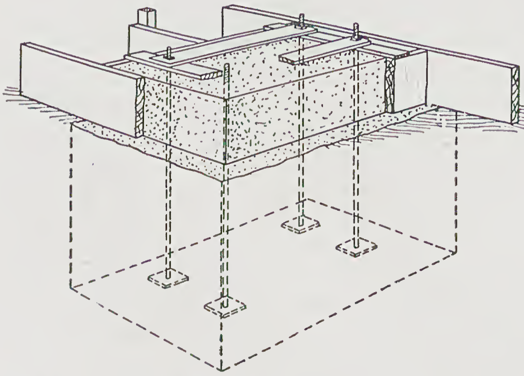
Concrete block foundation giving a non-continuous air space

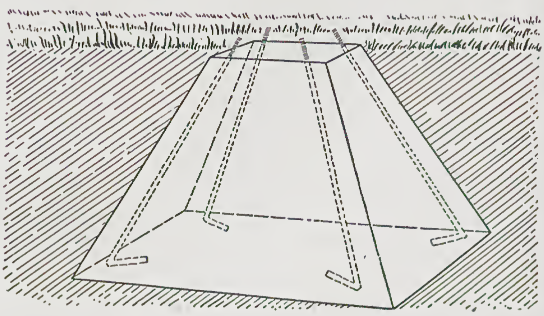
The appearance of an enclosure wall is important. Extra care to make good forms will be well repaid. Forms and their construction are described on pages 163 to 167. Under "Concrete Products," pages 76 to 92, details of post construction will be found.

The average enclosure wall is rarely more than six feet high, and the concrete is usually placed between forms by dumping from hand buckets or wheelbarrows. There is considerable opportunity to prevent monotony of appearance by a little forethought used when planning forms so that depressed or raised panels will be reproduced on the surface.

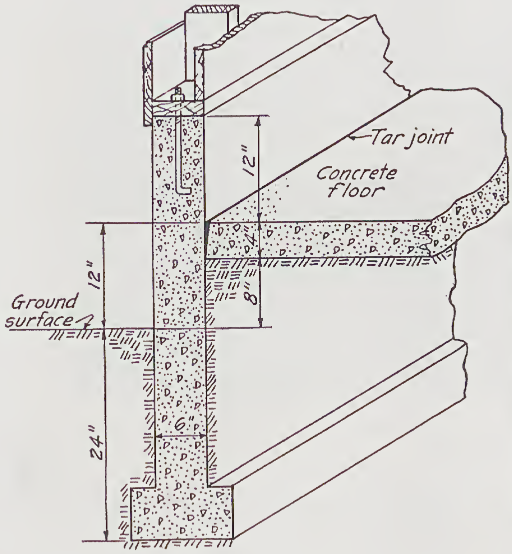
For walls above ground, where appearance plays an important part, the selection of a suitable surface finish can be made from those described on pages 176 and 177. Drawings and illustrations of enclosure walls are included under "Concrete Products."

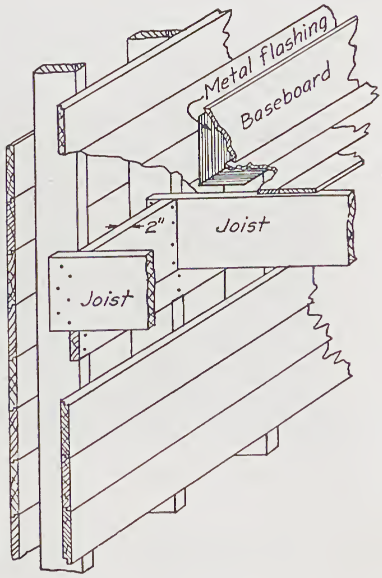
The principal reason for reinforcing concrete walls is to prevent cracking from possible settlement and from temperature changes rather than because of any need for supporting loads. An exception to the latter is in the case of retaining walls, such structures being constantly exposed to thrust from earth or water pressure. As expansion and contraction must be provided for in long stretches of walls, a suitable joint is introduced every 25 or 30 feet, unless the walls are so thoroughly and strongly reinforced as to throw all strains of expansion and contraction upon the reinforcing steel. Sometimes walls are built by plastering a skeleton framework of steel covered with wire mesh or expanded metal. Two or three coats of cement mortar are applied to the metal, producing the effect of a concrete wall.





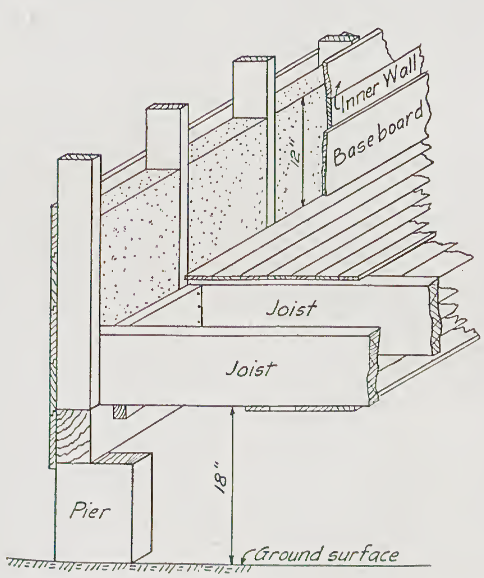
Concrete foundations are rigid. Engines, windmills, and cream separators need concrete foundations. These designs show how simple such foundations are to build. They require no reinforcement. Bolts can be securely fixed in the concrete to fasten the machine in position

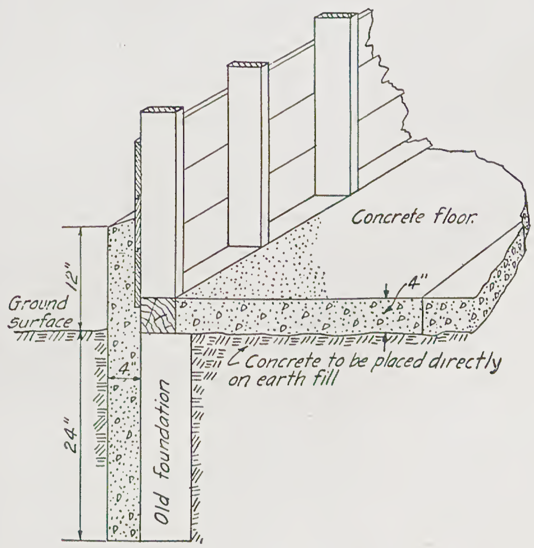




Building Out Rats

IN ADDITION to being great destroyers and wasters of food supplies, rats are a menace to health because they are plague carriers. In several coast states laws have been enacted that rats be built out of structures, and it has been recognized that the best way to accomplish this is by consistent and extensive use of concrete. Old buildings can be given an effective ratproofing by carrying up false foundation walls on the outside to such a height that the rats will find no resting place while attempting to gnaw through and into the building. Floors and foundation walls should be so joined that there will be no gap of earth through which the animals can burrow. The first step toward ratproofing is to see that all ground level floors are made of concrete. Foundations must be carried down far enough so that the animals will find it futile to burrow beneath them. All farm buildings should rest on concrete foundations and have concrete floors, even though they may not be constructed of concrete. Accompanying sketches offer suggestions.





Only a few simple tools are required. For a neat job a groover and an edger should be used

Floors, Walks, and Pavements

THE various classes of construction indicated by the above heading have been purposely grouped for description in a broad general way. Most of the principles that apply to one apply to all, particularly if the paving is laid upon the ground.

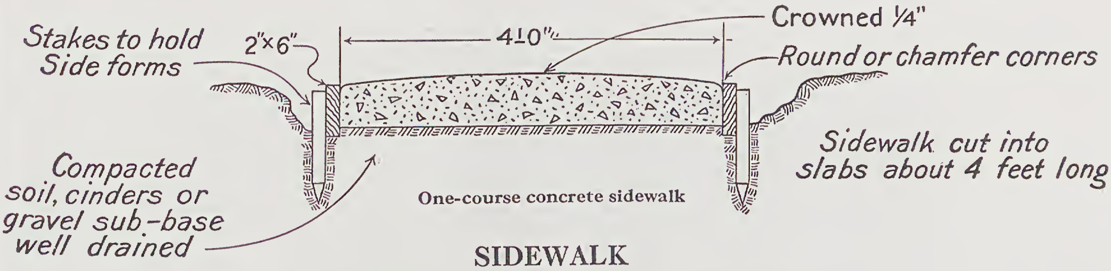
Concrete floors and pavements are a part of the complete home. The walks leading from the main sidewalk to the porch steps and around the side of the house to the back door and from the back door to the alley are necessary. If there is a garage, there should be either a broad pavement leading from the street to its doorway or a pair of parallel strips serving the same purpose. Any outbuildings on the home grounds should have concrete floors. No other type of floor should be used in a garage. Many houses are now being built with the basement completely concrete enclosed by building the first-story floor of concrete and the stairs leading to the basement of the same material, so that fires which may emanate from rubbish carelessly kept in the basement may not go beyond the source of origin.

The house heating plant should be concrete enclosed, with monolithic concrete or block walls and reinforced concrete floor overhead, so that the furnace will be completely cut off from the remainder of the house and made 100 per cent safe.

All classes of concrete floors and other pavements may be built along two general methods of construction. They may be either one-course or two-course. Until recently the latter type was more common. This consisted of a concrete base upon which was placed a concrete wearing course before the base had completely hardened, the base being of a lean mixture, such as 1 : 2½ : 5, and the top or wearing course being a rich cement mortar, such as a 1 : 2 mixture.

One-course construction, as its name implies, means that the walk or pavement is built throughout its thickness of one relatively rich mixture of concrete, such as 1 : 2 : 3 or 1 : 2 : 4. Considerable experience with one-course construction has proved it more reliable than the two-course type, largely because of careless workmanship so often prevailing in connection with the latter. Unless the mortar wearing surface is applied almost immediately after the base has been placed, the two courses will not unite firmly and in time will separate. Such a possibility is entirely removed with one-course construction.

Concrete pavements of any kind, indoors or out, resting immediately upon the soil, should lie on a firm, well-compacted base. Soft spots over the area to be paved should be dug out and filled with clean gravel, well compacted. For sidewalks, feeding floors, barnyard pavements, and all floors laid on the ground good drainage from beneath the pavement should be provided in whatever manner may be necessary. A specially prepared subbase of gravel or cinders is seldom necessary if the natural soil drains freely, is well compacted, and is sloped slightly so that free drainage is always present. If, however, the soil is dense and tends to be water-logged, particularly during



One-course concrete sidewalk

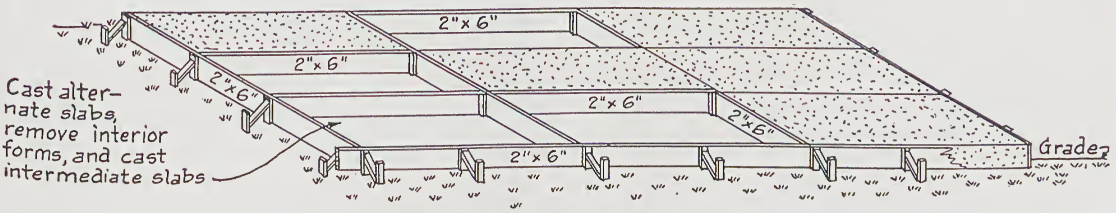
SIDEWALK

4 Feet Wide. (One Course.) 1 : 2½ : 5 Mix

Quantities per Lin. Ft. of Walk

$.417 \times 4 \times 1 = 1.668$ cu. ft. or .062 cu. yd. of concrete per lin. ft. of sidewalk

Lehigh cement	= .074 bbl.
Sand	= .028 cu. yd.
Pebbles	= .055 cu. yd.



General view of concrete feeding floor
(One-course floor, 5″ thick)

FEEDING FLOOR

18 Ft. by 18 Ft. Square. 1 : 2½ : 5 Mix

$$\frac{.417 \times 6 \times 6}{27} = \frac{15.02}{27} = .56 \text{ cu. yd. per } 6' \text{ by } 6' \text{ slab}$$

Material per Slab

6 by 6 feet

Lehigh cement	= .694 bbl.
Sand	= .26 cu. yd.
Pebbles	= .52 cu. yd.

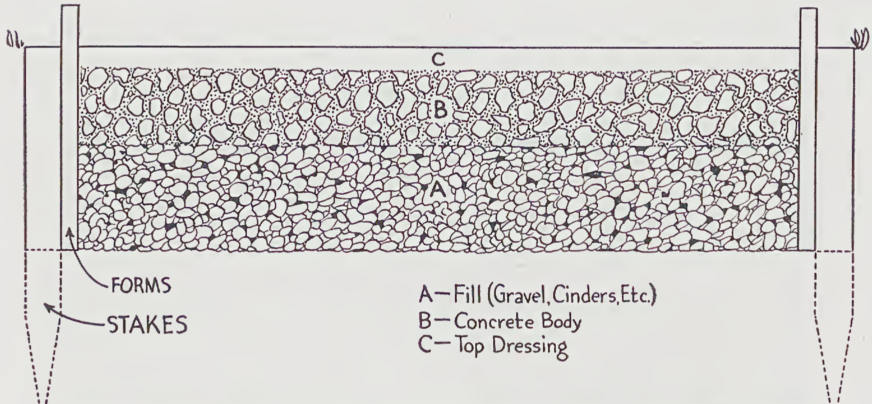
Material for Nine Slabs

Lehigh cement	= 25 sacks
Sand	= 2½ cu. yds.
Pebbles	= 5 cu. yds.

protracted rainy spells, then a special subbase of gravel or cinders may be necessary. Unless this is properly placed, however, it may cause more difficulties than would its omission. For example, if this subbase is so laid that it is in reality nothing but a filled trench, then it will be merely a sump that will collect water and make the walk unstable, especially if the water should freeze. The consequent expansion would heave the walk and break the slabs or throw them out of level. The same is true of any outdoor pavement. Because of the advantages mentioned, walks and other outdoor pavements are now more often of one-course construction than of the other type.

Concrete walks are usually laid in a continuous stretch, although they may be built by concreting alternate slabs first and intermediate ones last. An important point to observe is that each slab be completely independent of adjacent ones, that is, the joint marking the end of one slab and the commencement of another should be continuous through the concrete to the soil upon which it rests, then any slight disturbance of the walk due to upheaval or settlement can readily be corrected by raising or lowering the disturbed slabs as necessary.

The essentials of proportioning, mixing, and placing concrete have been described on pages 153 to 185. Ordinary sidewalks should be built not less than five inches thick. This also applies to feeding floors, barnyard pavements, floors in house cellars, or other buildings about the home except where loaded wagons use the floor as a driveway, then the thickness should be increased to six inches, and in some cases it may be advisable to reinforce the concrete to provide additional strength and safeguards against cracking. If



Cross-sectional view of two-course concrete sidewalk under construction. Below the fill all roots should be cut to 18 inches below ground

at any point a walk is crossed by a traffic driveway, then added thickness as well as risers must be provided at that point. See illustration on page 71.

Concrete walks and traffic pavements, regardless of their kind, are now seldom given final finish by using a steel trowel. Instead, a wooden hand float similar to a trowel is used and in this way the gritty non-skid surface texture secured.

In placing concrete for walks and other pavements practice developed recently has proved the advantage of rolling the concrete after placing on the subgrade, before final finishing, in order to compact it to utmost density and to remove excess water from the mixture. Street and highway pavements and private drives of average width are also given their first finish after rolling by passing to and fro across their width and advancing gradually along their length a wide canvas or rubber belt.

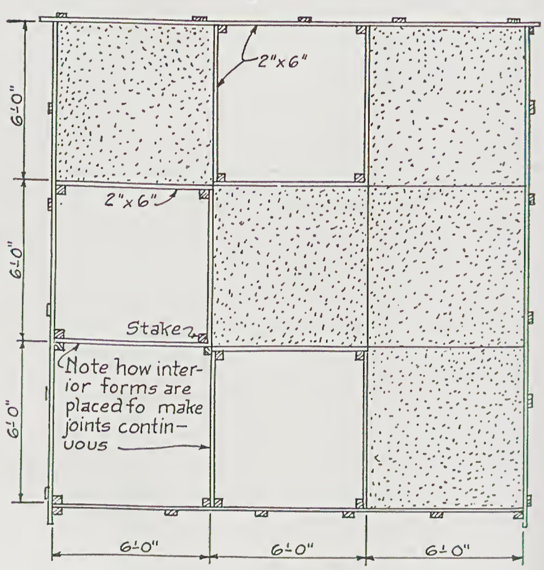
The most profitable uses made of concrete pavement on the farm are in flooring dairy stock quarters, paving the barnyard, building a feeding area in the hog lots, in fact, using it for floors in all buildings and for all outdoor paving requirements.

Concrete floors and pavements help to keep rats out of many buildings where their entrance would mean the loss or destruction of valuable foodstuffs, not to mention the probable carrying of disease for which these pests are notorious.

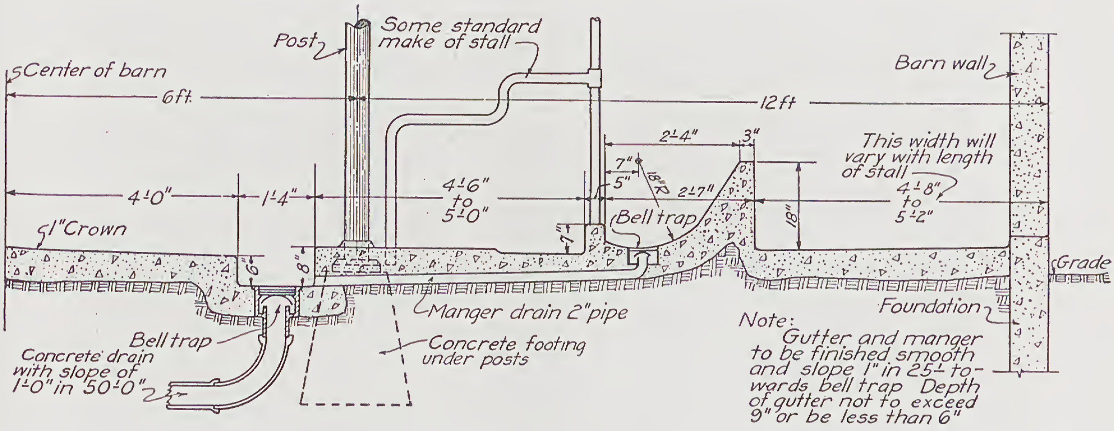
The profits of concrete hog feeding floors and barnyard pavements have been so well demonstrated by experiments in feeding, conducted by various state agricultural experiment stations, as to prove that no farmer can afford to be without one. Thus many a farmer has had proof laid before him that every year or at least two he feeds stock without a concrete floor he has lost through actual waste of grain, disease, extra labor required to keep quarters clean, rats, and other causes, enough money to cover the actual cost of paving or laying a floor on the area in question.

Feeding floors and barnyard pavements are usually composed of slabs about 10 feet square. Forms are set for a series of the slabs usually so that alternate slabs can be concreted first and intermediate ones last. In constructing the forms for the blocks of a feeding floor, care must be taken to stagger the adjacent divisions, in order to have continuous joints in the finished work, as shown in detail below.

The enclosure formed by the forms is filled with the mixed concrete, which is struck off as



One of the simplest types of concrete construction is the laying of a pavement, such as a concrete feeding floor



Design for manger, stalls, feeding alley, and manure drain

nearly level as possible by guiding a strike-board along the top of forms. The concrete is then rolled, if this is practicable. Usually a light steel roller, 10 or 12 inches in diameter, weighing about 75 pounds for a six- or eight-foot length, is used. After this the surface is finished by hand float or belt.

Surface drainage of all floors and pavements is usually accomplished by giving the whole pavement a slight slope in one or two directions. Concrete walks are often crowned slightly at their center. Barnyard pavements and feeding floors are sloped about ¼ inch to the foot toward a gutter, preferably built as a part of the floor, this gutter also sloping toward a drain connecting with a manure pit to insure conservation of all fertilizer.

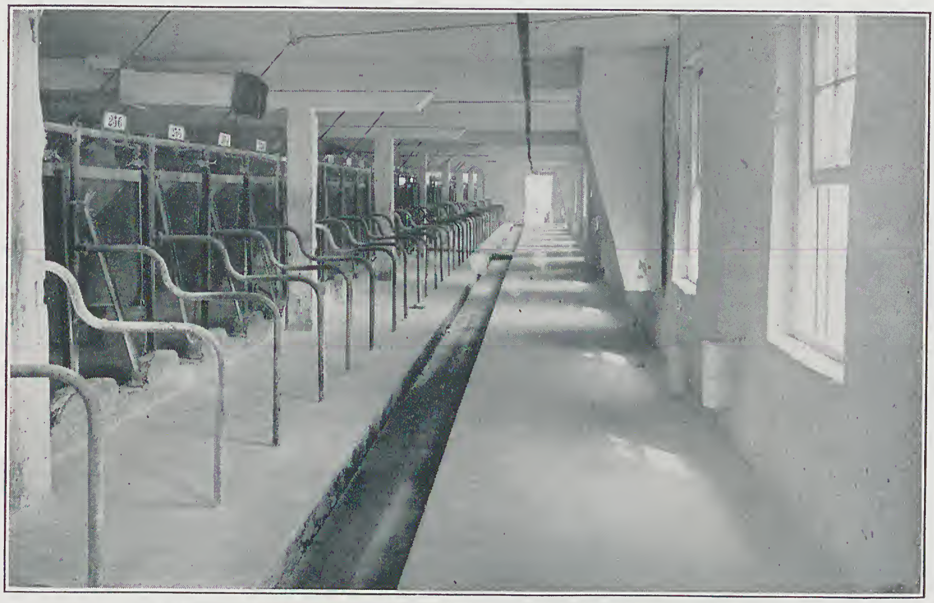
To prevent animals, while feeding, from shoving off grain on a concrete floor, a curb should be built around it. This is particularly true of a hog feeding floor. This curb should extend 18 inches below the base of the floor, so that the animals will not root beneath it and should project 2 or 3 inches above its top surface so as to prevent animals from shoving the feed into the surrounding dirt.

All floors supported only at their sides or edges must be reinforced. Such pavements as sidewalks, feeding floors, etc., resting on a firm subbase of soil, gravel, or other material, properly placed, do not, as a rule, need reinforcement.

A reinforced concrete floor which serves as a haymow floor, or basement ceiling of a general purpose barn, is one of its most valuable features. Within the last two or three years there have been several instances recorded of barn fires which broke out in hay-lofts and were prevented from completely destroying the barn because the reinforced concrete floor served as an absolute barrier.

It is not possible to give a standard design for such floors because the thickness, quantity of reinforcement required, and similar details

A small concrete feeding floor also affords easy access to the barn



A typical concrete barn floor. Its advantages have been mentioned in the text

depend upon length of span and load to be provided.

To avoid dusting of concrete floors there are several precautions that are absolutely necessary. Materials must be properly selected and prepared. Dirty sand should be washed. Too much fine sand should be eliminated. Overtroweling is objectionable and proper curing is essential.

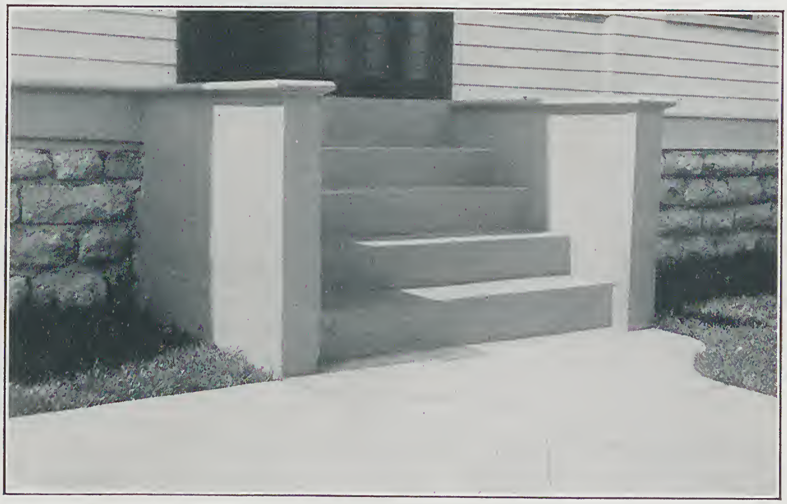
A properly cured floor is allowed to dry out slowly and the surface should be kept wet for several days. Drafts coming from under doorways are as likely to cause evaporation as excessive heat, and are to be avoided if a strong, dustless floor is to be secured. All traffic should be kept off the new laid concrete. Even though it may appear to be hard, it is not capable of carrying any load for several days. Its use before this time may result in cracking.

Concrete floors and other pavements will be dense and watertight if the concrete is properly proportioned, mixed to correct consistency, and given required protection after it is finished. Damp floors are due almost entirely to lean mixtures or to improperly graded ones. Special treatments to secure watertightness are not necessary if concreting has been done correctly. The subject of quantity of water has been discussed more fully in Section Three, page 158.

The problem of resurfacing old floors or walks frequently arises because of some neglect when construction was originally done. For example, in two-course floors or walks, as already mentioned, unless the top course is placed before the base has commenced to harden, there will not be effective bond between the two courses and in time they will separate. It is not difficult to make new concrete adhere thoroughly to old and thereby accomplish effective repair in cases such as mentioned, if the following simple precautions are observed:

All loose, disintegrated concrete must be removed and the surface thus exposed thoroughly cleansed by scrubbing with broom or brush and water. If the aggregate particles in this surface are coated with a film of cement, then this film should be removed by further washing with a weak acid solution consisting of 1 part of common muriatic acid to 3 or 4 parts of water. Just as soon as the acid solution has acted sufficiently to remove the cement film, the surface thus being treated should *immediately* be washed *thoroughly* with clean water. The concrete mixture properly prepared for doing the repair necessary is then applied to this cleansed surface. As an added precaution the surface may be painted with a grout consisting of cement and water mixed to a creamy consistency and the plaster coat immediately applied and well troweled on the surface.

Top finish should be worked sufficiently to give it a strong bond to the base course, but the surface should not be troweled too smoothly.



Concrete steps with cheek walls

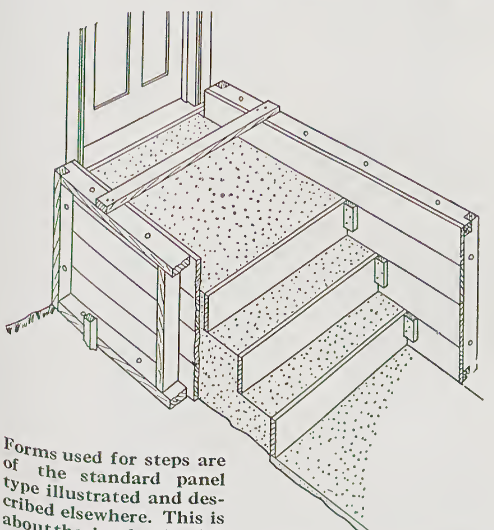
Steps and Porches

HOW often do we see a quite attractive house or other building with porch and steps sagging or breaking away from the structure all because built of short-lived material? Wood in contact with the soil is exposed to alternate moist and dry conditions. Probably no home built originally with wooden porches and steps has escaped the necessity of having this part of the structure repaired frequently or entirely replaced. Each time repair or renewal is necessary and the use of concrete is omitted in that connection, just so much time, labor, and money have been wasted.

The skill required to build a simple porch and steps for the average building is not beyond the range of the home worker. Forms are simple, and no special tools are required that cannot be found about every home. A combination of the principles of construction applying to "Floors, Walks, and Pavements," on pages 64 to 68, makes up the practices governing the building of steps and porches.

A design for reinforcing concrete porch floors of certain width is shown below, which will enable any one to build a complete concrete porch.

The table accompanying this design permits the adaptation to widths from four to ten feet inclusive with respect to thickness of slab and size and spacing of reinforcing.



Forms used for steps are of the standard panel type illustrated and described elsewhere. This is about the simplest kind of concrete work, and dimensions of steps or porch landing may be varied at will by variation in setting of forms

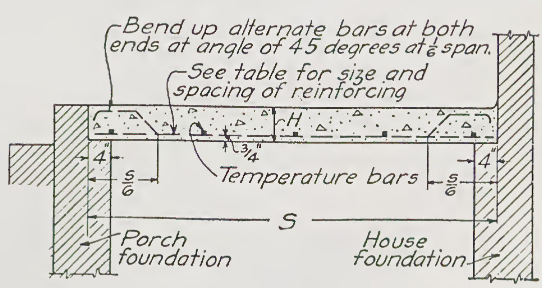
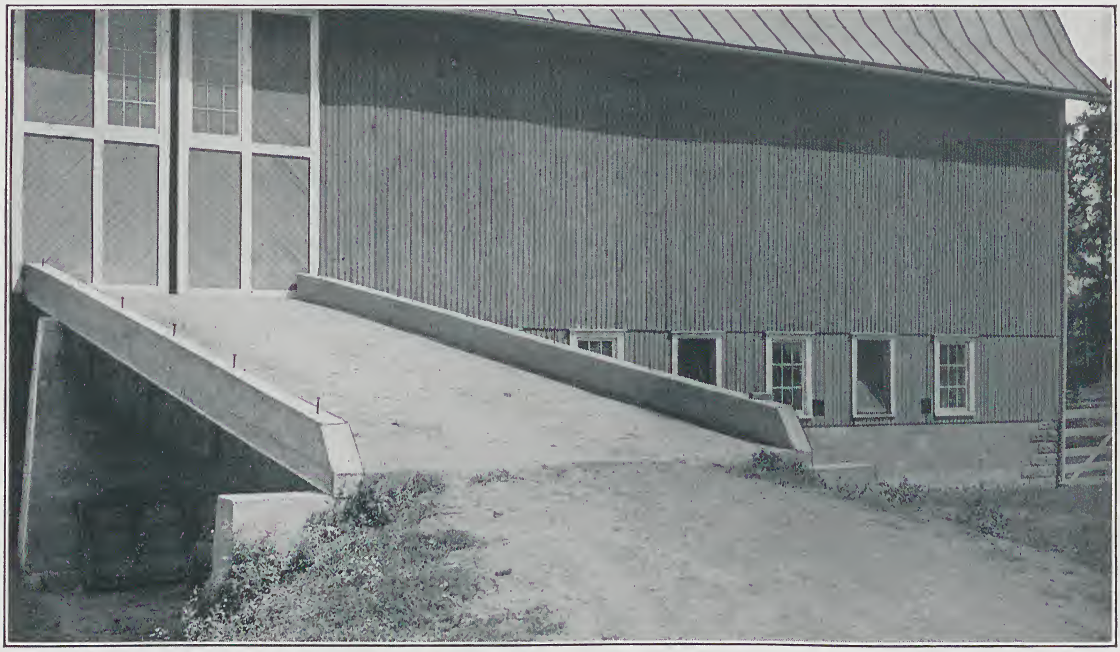


TABLE			
S	H	Size of rods	Spacing of rods
4'-0"	4½"	¼"	8"
5'-0"	4½"	¼"	6"
6'-0"	4½"	⅜"	9"
8'-0"	5"	⅜"	6"
10'-0"	5"	⅜"	4"

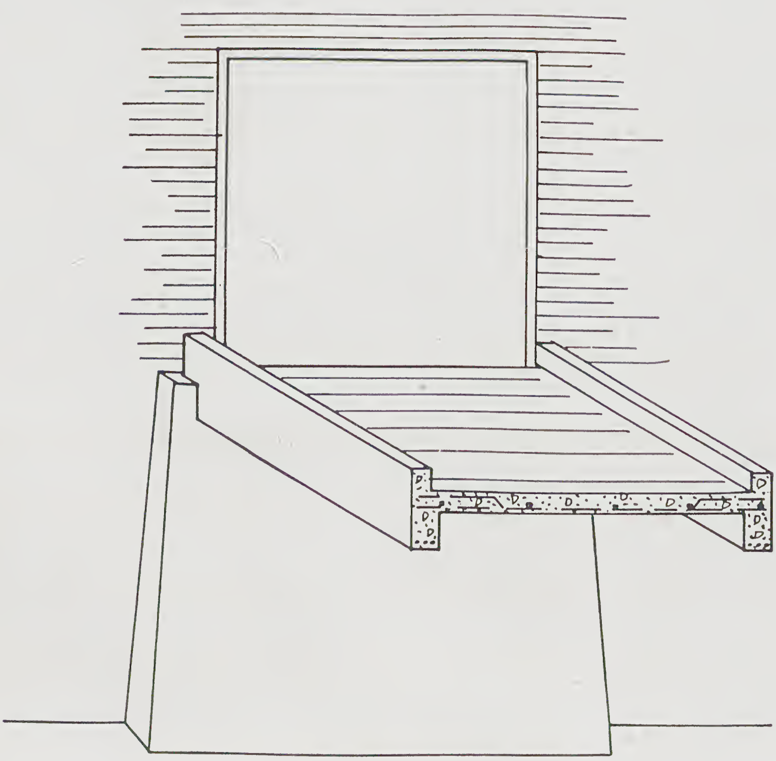
Porch floor design calculated for widths ranging from 4 to 10 feet. The table shows the thickness of floor, size and spacing of rods for each particular variation in width

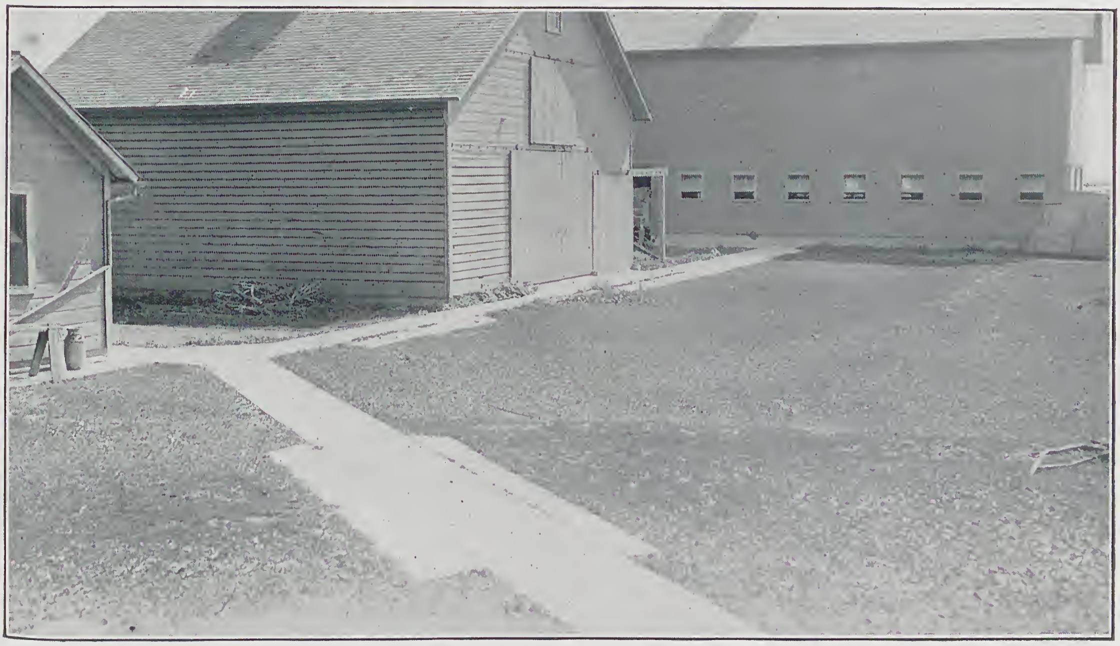


The protecting curb serves also as a supporting beam

Barn Approaches

THE construction of a barn approach must be planned so that the span will accommodate heavy loads. The reinforcement necessary and the thickness of the span are important factors, and the services of some one experienced in this class of work should be secured.

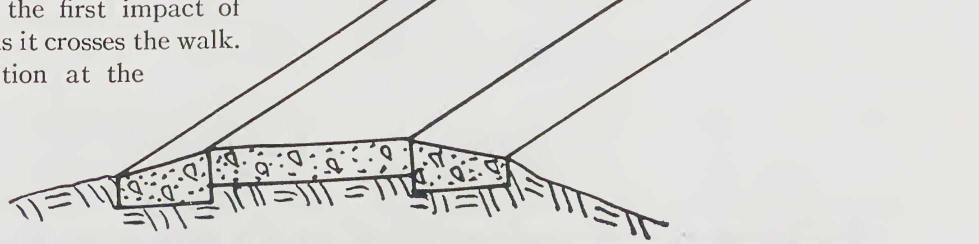


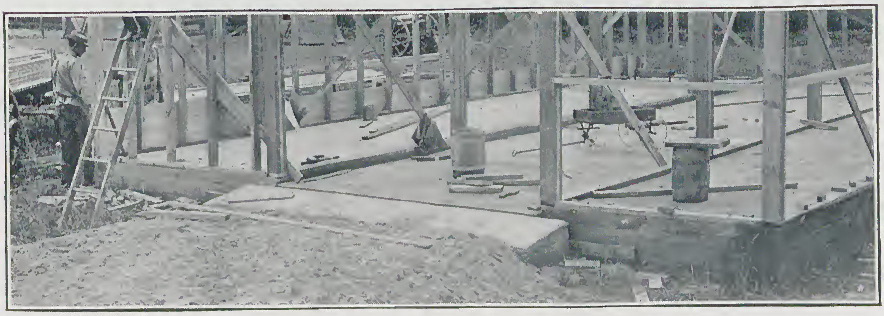


Crossover and Riser

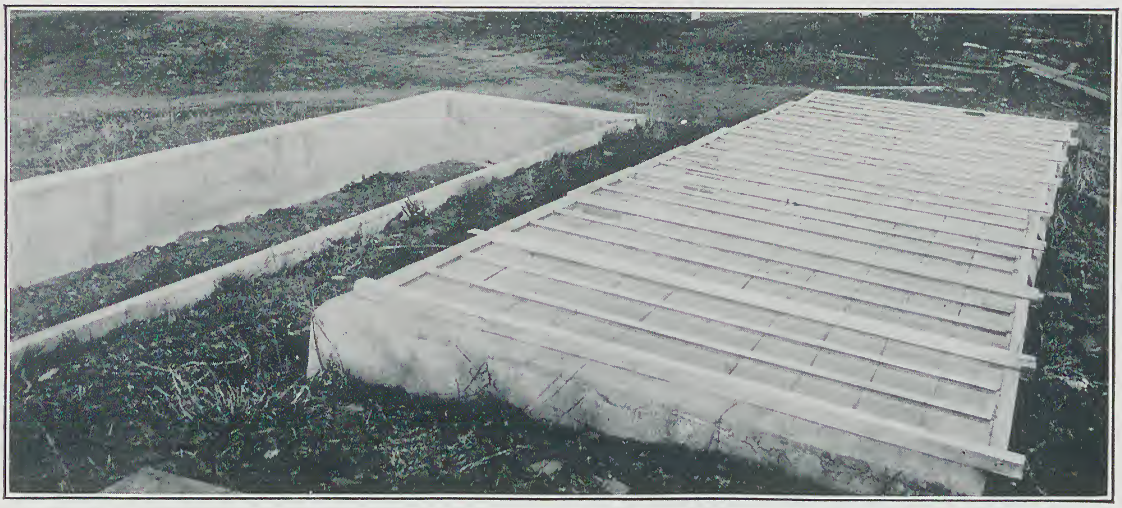
CONCRETE walks on the farm or around home grounds relieve the housewife of much of the drudgery of housecleaning. Men folks have no excuse for muddy boots where a concrete walk leads from the rear porch to the outbuildings, if, in addition, the barnyard and feed lot are concrete paved.

Accompanying views show how a concrete walk should be protected where provision must be made for loaded vehicles to cross it. Two strips of concrete, one on each side, slope away from the walk level in order to provide for the first impact of the vehicle as it crosses the walk. The illustration at the bottom is a suggestion for an entrance riser. The type of construction is the same as for the crossover. Additional information about concrete pavements and walks is given on pages 64 to 68.



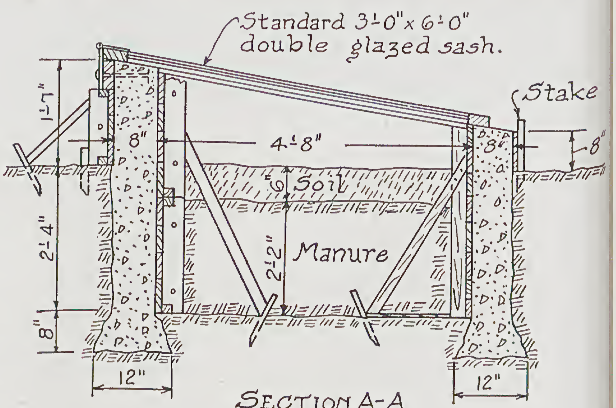


A riser eliminates jolt and reduces strain

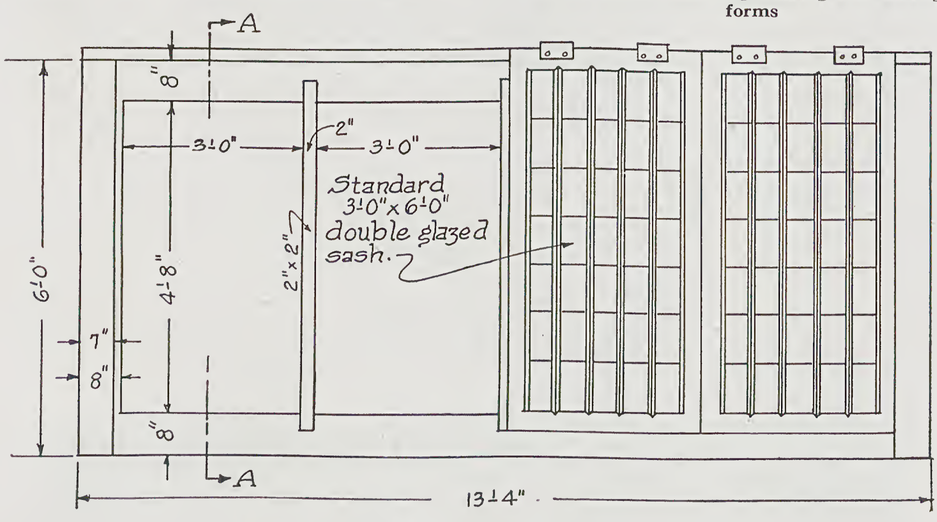


Hotbeds and Cold-Frames

A HOTBED should be located so that it slopes toward the south, and should be protected from cold wind. The standard hotbed sash is usually three by six feet. Average home requirements will be met by a bed large enough to require four sash to cover. For commercial needs any desired size can be obtained by increased length. In some cases hotbeds are so made that after they have served for producing the early out-of-the-season



Vertical section showing bracing and arrangement of forms



HOTBED—1 : 2½ : 5 Mix

SIDES

High side
5′ × .67′ × 13.33′ = 44.65 cu. ft.

Low side
4′ × .67′ × 13.33′ = 35.72 cu. ft.

Ends
4.5′ × .67′ × 4.67′ × 2 = 28.17 cu. ft.

108.54 cu. ft. or 4 cu. yds. of concrete

Material Required

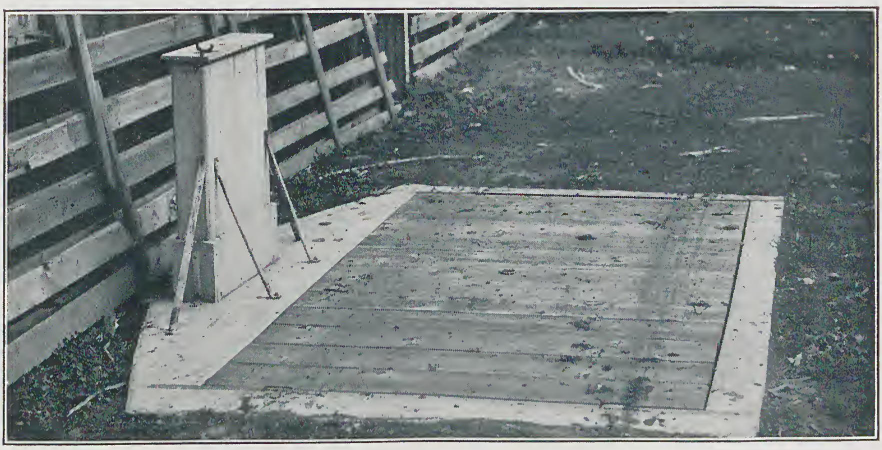
Lehigh cement	= 5 bbls.
Sand	= 2 cu. yds.
Pebbles	= 4 cu. yds.

crop, sash and supporting frames can be taken off and other crops raised in season.

Center bars supporting the sash frame are of strong material, shaped like an inverted "T." T irons are preferable to wood. The hotbed walls should be six or eight inches thick, and carried down below possible frost penetration. Inside forms can be set up, roughly supported by stakes and braces. After set they should be checked to see that the dimensions of the bed have been correctly laid out for the size of sash to be used.

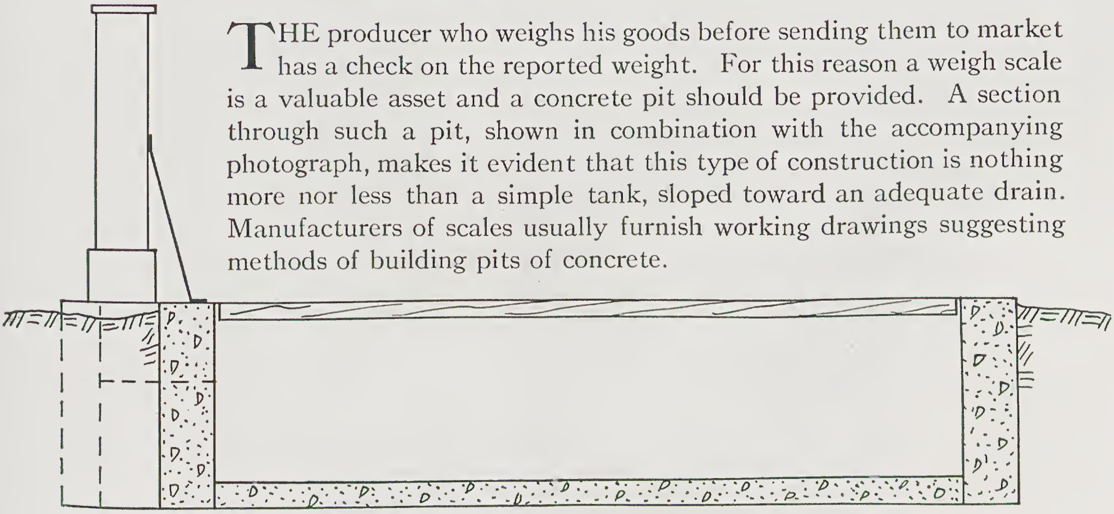
If the bed is to be used as a cold-frame, the proper amount of soil is thrown back into the excavation when concreting has been finished and the bed covered with the glazed sash, warmth of sun only being used to propagate and stimulate growth of the crops. To operate as a hotbed the excavation should be at least two feet deep measured from outside ground level, in which is packed 18 inches of fresh stable manure well mixed with leaves. This should be covered with four to six inches of rich fine soil. After the sash is put on the temperature of the inclosure will begin to rise rapidly, due to the heating of the manure. A thermometer should be placed so that it can be determined when the temperature has dropped to 85° or 90° Fahrenheit, after which seed may be planted.

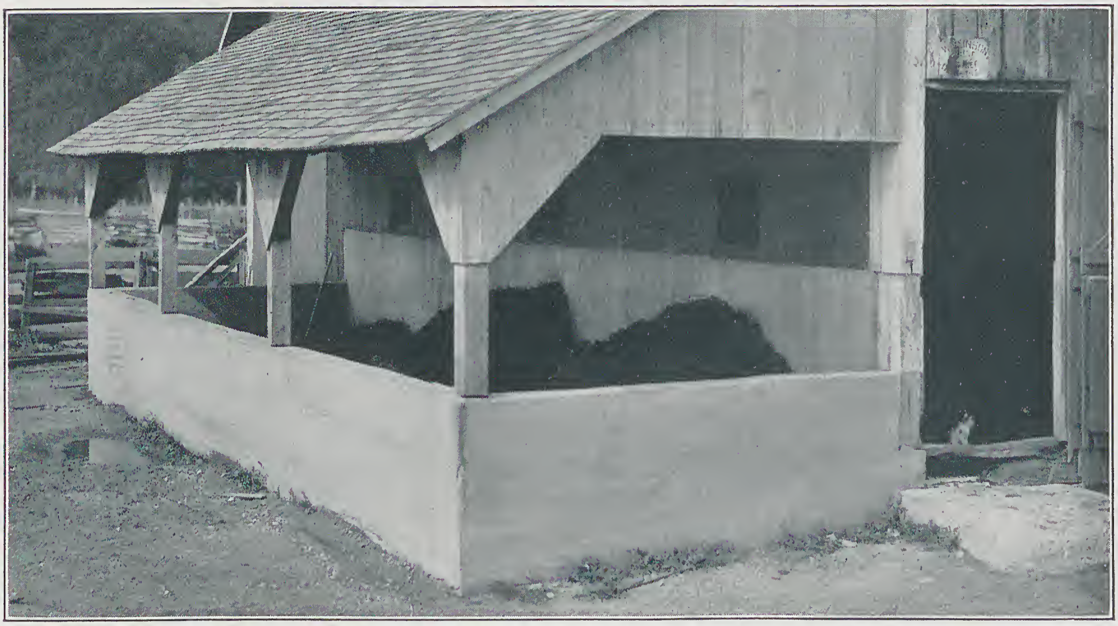
Construction details, given under the heading "Foundation and Walls," pages 57 to 62, apply to the concrete portion of hotbeds. Reinforcement is not necessary unless the walls exceed 25 feet in length, when two ¼-inch rods may be laid at the center of the wall, 4 and 18 inches respectively from the top, to prevent cracks from temperature changes. In any event it is well to bend three- or four-foot lengths of ¼-inch rods around each corner to prevent cracking at corners.



Scale Foundations

THE producer who weighs his goods before sending them to market has a check on the reported weight. For this reason a weigh scale is a valuable asset and a concrete pit should be provided. A section through such a pit, shown in combination with the accompanying photograph, makes it evident that this type of construction is nothing more nor less than a simple tank, sloped toward an adequate drain. Manufacturers of scales usually furnish working drawings suggesting methods of building pits of concrete.





A covered concrete manure pit

Manure Pits

A MANURE pit is a form of tank. It should be tight enough to hold the liquid contents of manure, which are the most valuable part. It is also desirable that a pit be roofed over to prevent excessive rains from keeping the manure so wet that its decomposition cannot be properly controlled.

Manure pits are made in various ways, depending upon the quantity of manure to be handled. Some are built so that the top of side walls is level with the ground, some are built so that the floor is nearly at ground level and the side walls two or three feet above it. In the latter case the pit generally has an opening at one end so that wagons can back into it for convenience in loading manure.

If any considerable quantity of manure is to be stored for an unusual length of time, the pit should have a cistern at one end into which excess liquids can drain and from which it can be pumped at intervals as necessary.

Ordinarily the floor of a concrete manure pit requires no reinforcement. The side walls must be reinforced to take care of earth pressure and the pressure of manure in the pit.

The capacity of a pit will be regulated by the stock kept. A pit 24 by 20 feet is large enough to accommodate the stable waste from about 15 cows. The pit should be located so that it is directly in line with the cleaning alley in the barn, thus making a straight run for the litter carrier from barn alleyway.

Construction details applying to "Floors, Walks, and Pavements," pages 64 to 68, make up the essentials to be observed in building a concrete manure pit. Joint between wall and floor should be sealed with hot tar to prevent leakage.

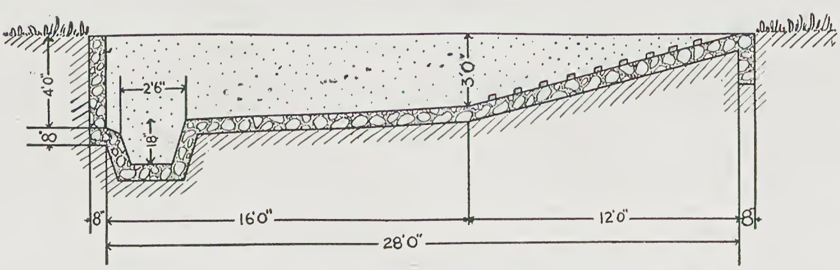
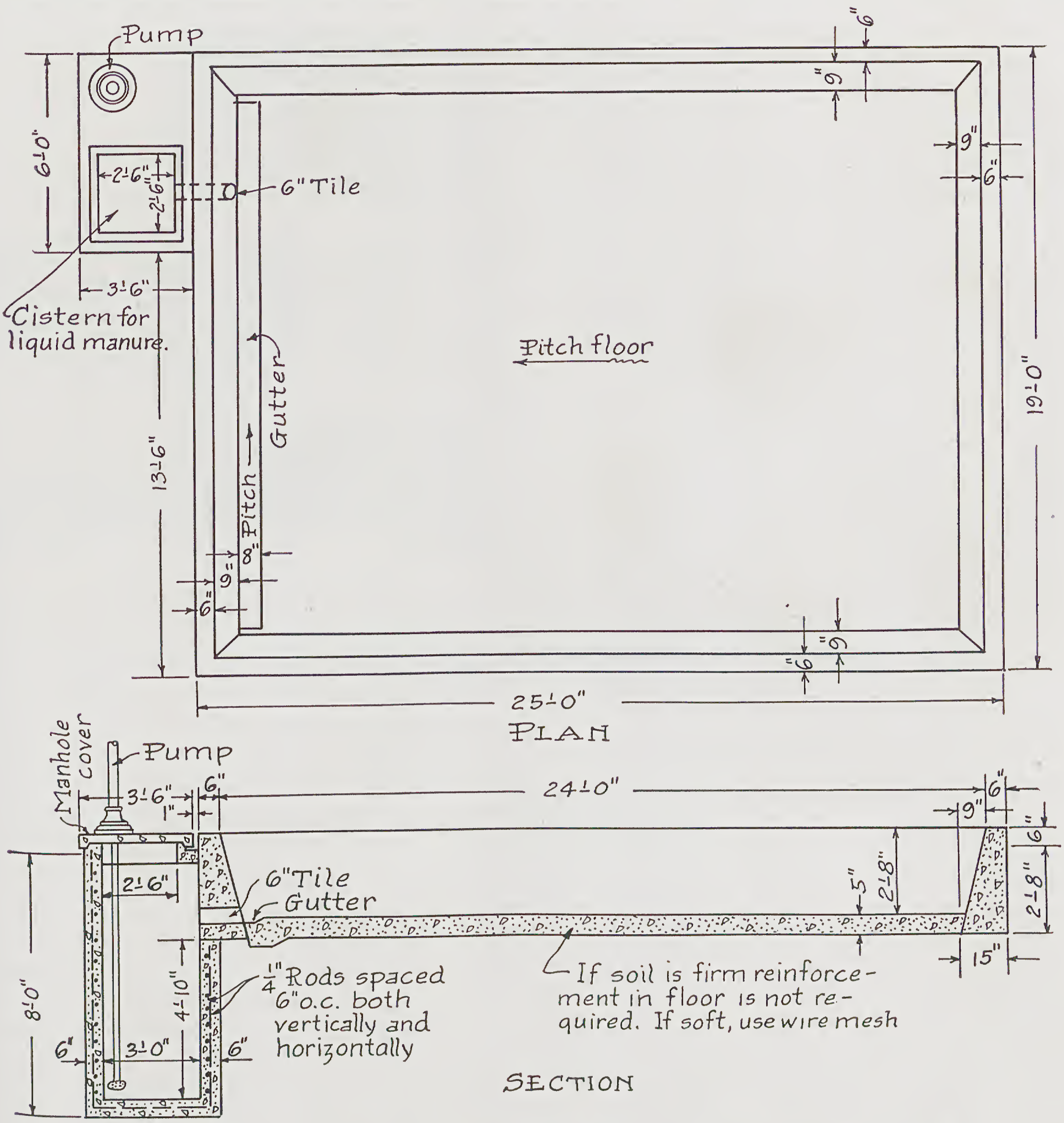


Diagram of manure pit with cleats to provide foothold for horses



This design shows a pit with a cistern. The idea of the cistern is to collect excess liquids from the manure and from which periodically the contents can be pumped and distributed over the fields. Most farmers know that the liquid content of manure contains its most valuable fertilizing elements

MANURE PIT

Pit: 1: 2½: 5 Mix. Cistern: 1: 2: 3 Mix

PIT

Side walls	225 cu. ft.
Floor	148 cu. ft.
	373 cu. ft. or 14 cu. yds.

Material Required

Lehigh cement	= 17.5 bbls.
Sand	= 6.5 cu. yds.
Pebbles	= 13.0 cu. yds.

CISTERN

= 80 cu. ft. or 3 cu. yds.

Material Required

Lehigh cement	= 5.0 bbls.
Sand	= 1.5 cu. yds.
Pebbles	= 2.5 cu. yds.

Reinforcement

¼″ round rods = 612 lin. ft. or 104 lbs.

Concrete Products

Their Manufacture and Use

UNDER "concrete products" a great and widely differing variety of units may be listed. Among these are concrete block, concrete brick, concrete structural tile, concrete roofing tile, cement asbestos shingles, architectural trimstone, such as sills, lintels, medallions, porch columns, balustrades, bridge rails, and stair spindles; gravestones and grave-markers and burial vaults; drain tile, sewer pipe, and a large variety of garden and lawn furniture, such as seats, sun-dials, pedestals, fountains, flower-urns and boxes, and an almost endless variety of statuary. Under the same heading come concrete posts in numerous variety, including those used for ordinary fences, gate posts, mail-box posts, highway markers, street signs, railroad signals, arbor and grape-vine trellisis, ornamental lamp-posts or lighting standards, and pergolas.

There seems an almost boundless field for developing new products and extending the uses of old ones. The rapid transformation of our highways from muddy lanes to permanent pavement makes an inviting market for sign and guide posts, and the popularity of so-called concrete staves used for building concrete stave silos is not confined to the structures for which they were originally designed, for with but slight modification concrete silo staves are now being successfully used to build grain bins, barns, enclosure walls, and many small buildings, such as garages, milk houses, and the like.

Block, Brick, and Structural Tile

Concrete block are made in a wide variety, although the object sought in all is to attain a building unit that will insure in some form or another at least 33 per cent of air space in the wall in which they are used.

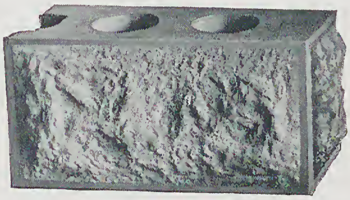
Very few home users of concrete are justified in attempting to make any of the ordinary commercialized concrete products on any considerable scale. To turn out high-grade products requires an investment in plant and equipment that the casual user of concrete is not prepared to make.

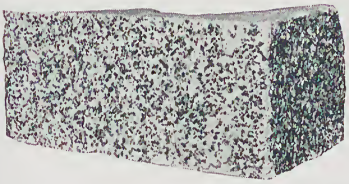
There seems no limit to the structural possibilities of the ordinary run of concrete products, such as block, brick, structural tile, and architectural trimstone. New uses and new applications for many of these products are being developed daily. Every new use means a new market previously untouched. One of the greatest immediate markets for concrete block and concrete structural tile is for building concrete garages and houses. Especially designed machines are used in the manufacture of the principal concrete products in the structural field, and such products as drain tile, sewer pipe, and culvert pipe are made by machine.

Choosing a Machine

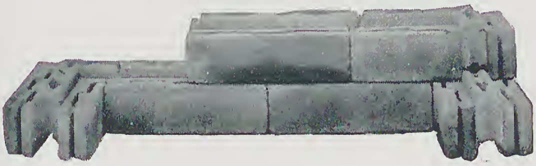
Whether concrete products are manufactured for limited personal use by the maker or to meet commercial needs, their quality, as that of any other concrete, depends upon the observance of good concreting practice. In selecting a machine for the manufacture of any concrete product great care should be exercised so as to insure its adaptability to the production of a commodity of high standard meeting all of the present-day requirements. A block machine, for example, should be chosen that will permit the use of just as wet a mixture as possible without causing slump or deformation of the product when removed from the mold. It should be adaptable to making various patterns of molding and trim and concrete brick, unless the manufacturer intends to cater to the concrete brick market, in which case a machine exclusively for brick should be purchased.

More and more is the tendency toward discarding the early type of imitation rock-faced block and producing instead a product that rivals in beauty and appearance natural cut stone. Since many of these effects, both in brick and block, are produced by using facing mixtures, choice of a machine must be made with consideration for making a faced product. It may be necessary to have variations in types of machines for the same product, so that a block having certain types of air space can be manufactured to meet a popular demand already created in the community. There must always be provision for making





Concrete blocks rival in beauty and appearance the finest cut stone. They have the advantages of being fire resistant and permanent



reasonable adjustment as to thickness of wall and height of courses, the latter in order to secure the pleasing effect of alternating wide and narrow courses, as well as to provide for courses of unusual height when certain building requirements demand it. Adjustments should also provide for varying length of block to make units that will fit any dimensions of an architectural plan. Concrete block are made by either the pressed or the tamped process.

What has been said of concrete block and the machines used to manufacture them applies in the same general way to concrete brick and to concrete structural tile. The appearance of a properly designed concrete building made of any of these three units can easily surpass that of any other type of construction of like cost.

Mixtures to Use

All concrete products are made of either ordinary concrete or mortar mixtures. Where a true concrete mixture is used, the maximum size of coarse aggregate used seldom exceeds ¾ inch, and in some cases not more than ½ inch. However, in the manufacture of large sewer and culvert pipe and drain tile, the shell thickness of the pipe governs the size of aggregates. In the small sizes of drain tile and in the manufacture of concrete brick so-called mortar mixtures are used. These should not be leaner than 1:3.

The maximum size of aggregate is often governed by the use to which the product is to be put, the kind of surface finish it is to have, or the after-treatment to be given it in order to secure a certain surface appearance. In the commercial manufacture of concrete products capacity production is demanded, so that mixtures used generally contain less water than would be permissible in ordinary concrete construction. This deficiency should never be extreme. All concrete products should be made of as wet a mixture as is possible to be used with the machine in question, and because of the necessity of using less water in the manufacture of some products, greater care must be taken to protect them while curing.

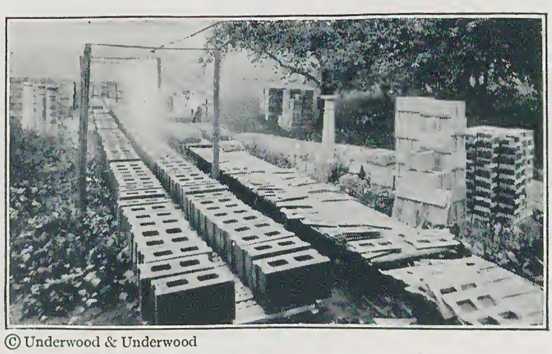
Hydrated Lime

In the manufacture of some concrete products, particularly block, a small quantity of hydrated lime is sometimes added to the mixture in order to give the product a lighter color. The quantity to be used should be that which will not lower the quality of the product below the required standard.

If waterproofing compounds are used, the method of using should be according to the manufacturer's recommendations, which lay particular stress on recognized fundamentals of good concrete practice.

Machine mixing of concrete for products manufacture is by all means to be preferred to hand mixing.

Block and brick are given distinctive facings by using different mixtures than are employed in the body. These mixtures contain selected aggregates, often with a small amount of mineral coloring-matter combined with the cement in order to produce a particular surface texture and color. Facing and body mixtures should be very nearly of the same consistency. All materials of the facing mixture should be thoroughly mixed while dry, and the same quantity of water and of coloring-matter should be used in each batch,



Concrete blocks are cured by spraying them with water so that hardening takes place gradually

otherwise they will vary in color. See tables on page 183.

Both block and brick machines are available in hand- and power-operated types. In each type provision is made for air space in the wall, and the means by which this is secured varies widely.

Block that extend through the wall are termed "one-piece block." The outer part is called the face section and the inner part the back section, and the partitions that unite the face to the back are called webs. All such block are correctly termed "hollow block." There are types of block which permit laying a wall having a continuous air space. Such block are known as "two-piece block." The more common forms are designated as "T" shape, "L" shape, and "V" shape, because their general outlines conform to the shape of these letters. In all systems of block construction the open spaces are arranged to form continuous flues from the bottom to the top of a wall. They may be used to ventilate a structure, and for placing electric wiring and service pipes.

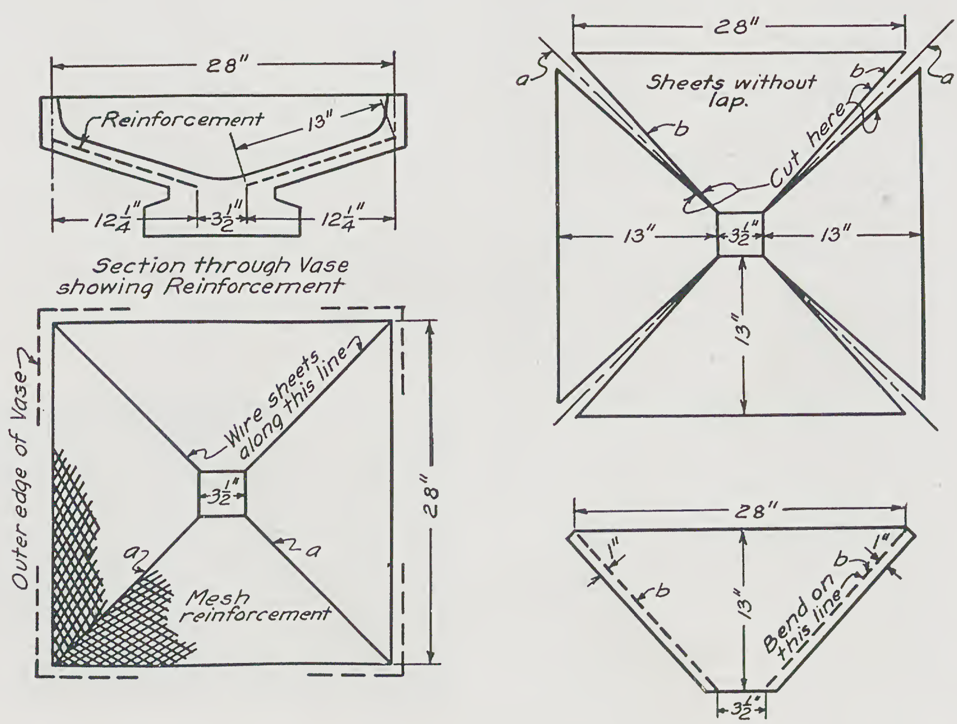
Products Should be Tested

Tests are particularly necessary on such concrete products as block, brick, and all kinds of pipe and tile, to determine that a uniformly high-grade product is being made. An indication of the strength of any product is the fracture of the aggregate when the product is broken. This indicates that the cement has performed its full binding function and the product is as strong as can be with the aggregate used.

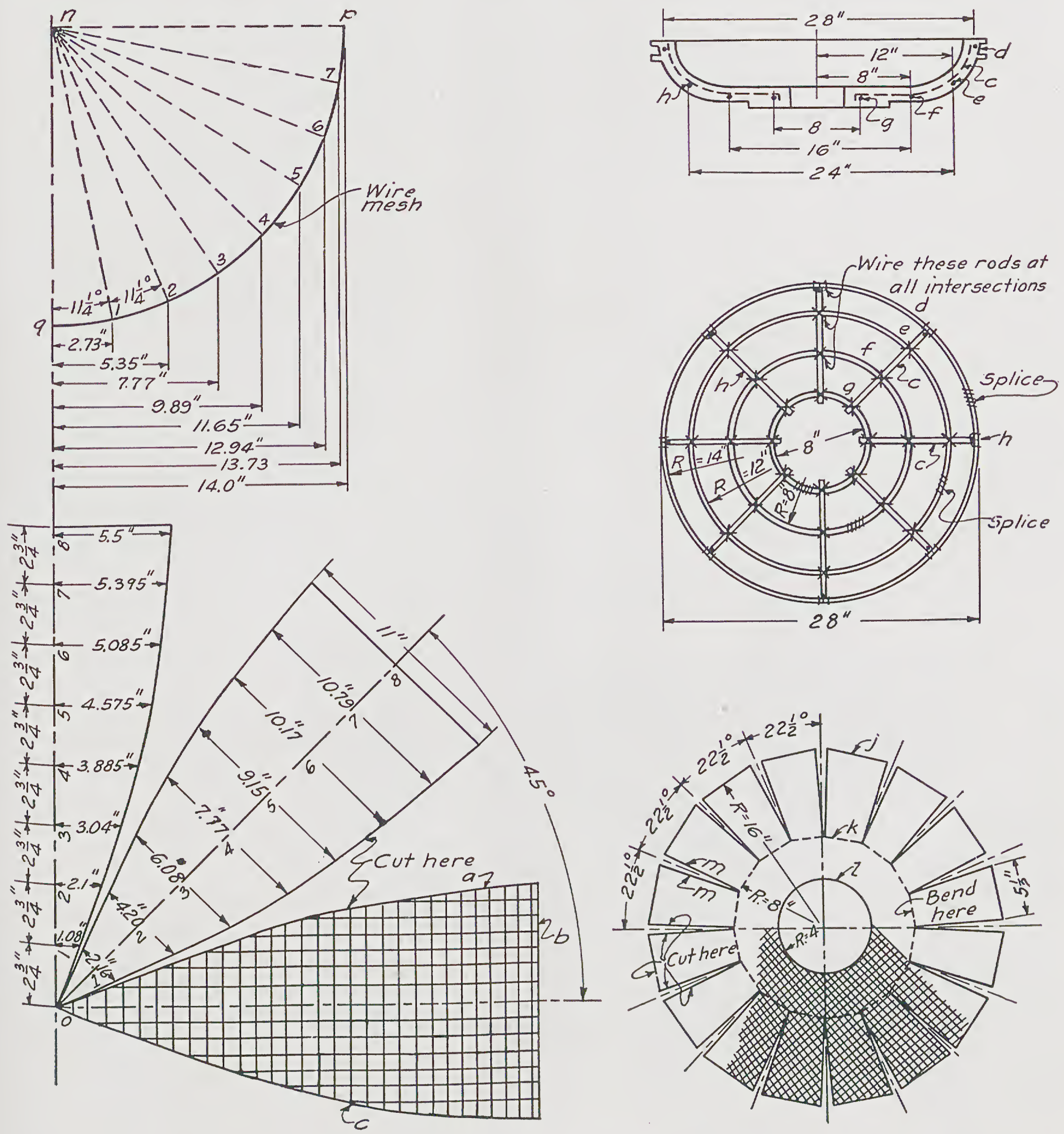
Such concrete products as ornamental garden or lawn furniture present an opportunity to the home worker to display considerable ingenuity and will give him useful and lasting returns for his efforts.

There is considerable difference between the molding of structural units and the successful casting of ornamental products. Very small imperfections may seriously mar their appearance. Great care should be taken in the preparation of the molds and in the placing of the concrete. For thin objects a selected aggregate should be used throughout, but where the thickness of the concrete will permit, a backing made with a plain aggregate will prove an economy.

Much of the success in making ornamental products depends upon perfect molds and the methods by which they are filled. The concrete mixture must be somewhat wetter than would be used in ordinary work, so that it can be made to settle to all parts of the form.



The information about this layout is found on the next page

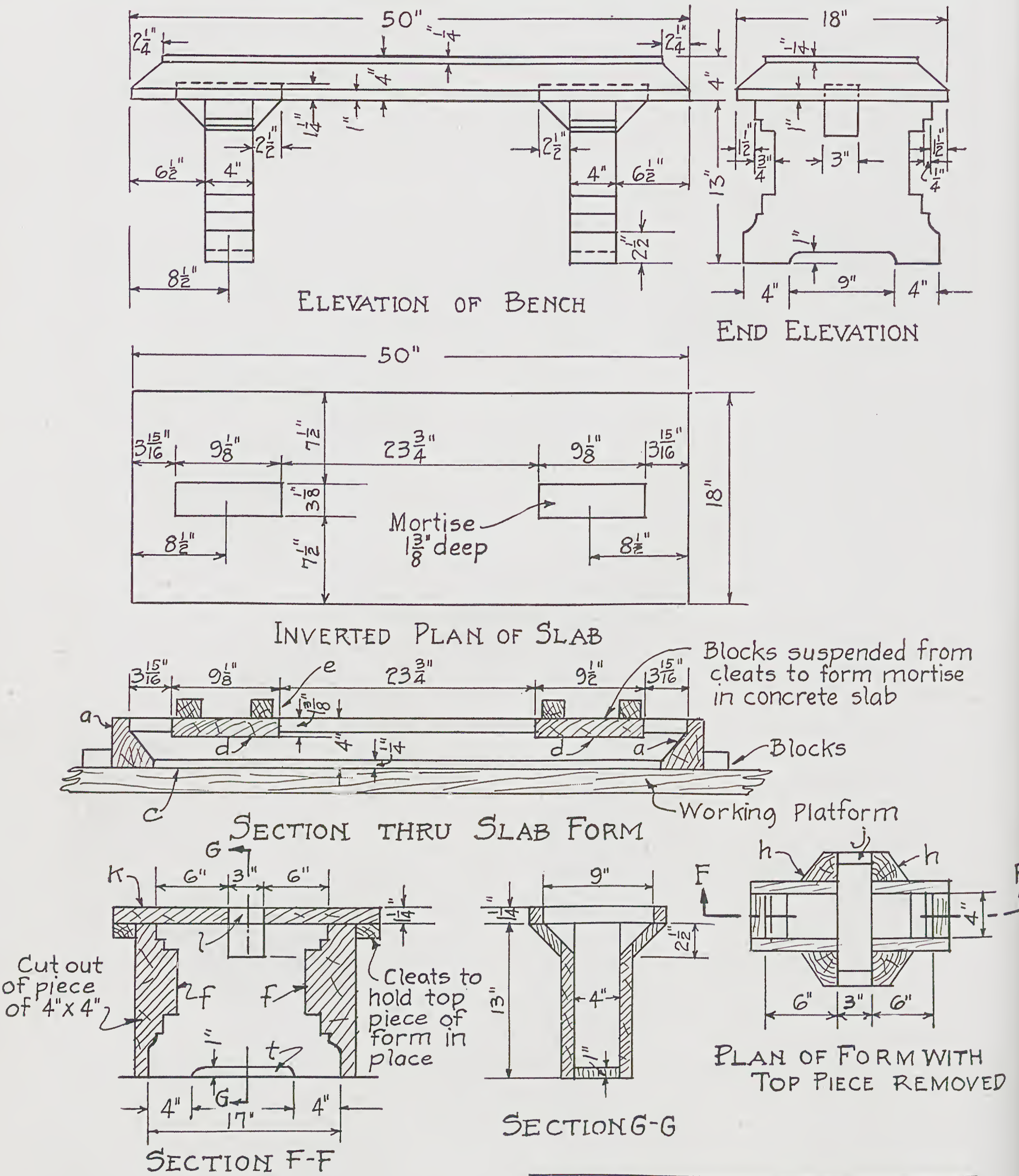


Instead of plain steel rods or wires for reinforcement, expanded metal or wire mesh may be used, and in many cases will be preferable. Whenever expanded metal or wire mesh is used for such purposes, it will be necessary to cut the flat sheets so that the reinforcement when bent up will conform to the lines of the product. This is called developing the sheet of reinforcement. After the necessary cuts have been made, the sheet should be bent along the dotted lines, as shown on page 78, and the laps securely wired with black tie wire. If the bowl is larger in diameter than the one shown, a greater number of radial cuts may be required

When the bowl is flat, such as the one referred to, these radial cuts may be made as shown, but if the bowl is hemispherical, it will be necessary to cut the sheet as shown. This illustration shows a convenient method for laying out such developed sheets. In this case the flat sheet is composed of eight equal sectors, two and one-half of which are shown above. When these sectors are bent up so that their edges meet, they will form a hemisphere. The length of the flat sector along the center line is equal to the length of the arc of a circle shown in the upper part of the drawing. In this example it was found convenient to divide the sector into eight equal parts, each 2¾ inches long. The 90 degree vertical arc is also divided into eight equal parts, the length of each part measured on the circumference being equal to 2¾ inches. The dimension at the outer edge of the flat sector, 11 inches, is equal to one-eighth of the circumference at the outer edge of the reinforcement at *p* when the sectors are bent into the form of a hemisphere. The dimension 10.79 inches is equal to one-eighth of the circumference at the point (7) in the half vertical section through the wire mesh with a radius of 13.73 inches. The dimension 10.17 inches is equal to one-eighth of the circumference at (6) when the radius is 12.94 inches. Each successive dimension toward the center of a sheet at (*0*) is equal to one-eighth of the circumference at its respective point shown in the half vertical section. The developed sheets for hemispherical bowls of any diameter may be laid out in a similar manner. A practical illustration of developing these sheets may be had by cutting an orange in two equal parts and slicing the peel into eight equal parts from the circumference of the orange to the bottom, and laying the eight sectors thus formed flat on a table. The shape of the orange peel sectors will be almost identical with the sectors shown in plan above

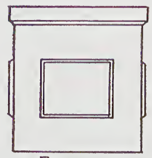
The developed sheet for square bowls is shown on page 78

It is important to wire all edges of developed sheets firmly in order to secure the necessary strength required from the reinforcement, that is, to get the effect of continuous reinforcement

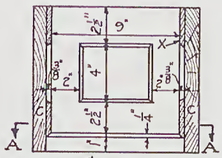


Details for a garden bench. The form for the seat slab consists of part *a*. This has mitered joints and as assembled is held in position on the workbench by small blocks. Part *a* when made of the shape shown should always terminate in a small member, *c*. If the curve is brought down to a feather edge, the concrete soon slivers off. Mortises are formed by holding part *d* in position shown by means of cleats *e* extending across the top of form

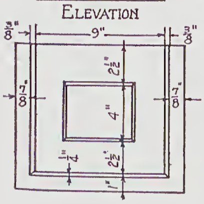
Forms for legs consist of *f*, *g*, *h*, *j*, *k*, *l*, and *m*. Piece *f* is cut out one piece by a band saw and the surface smoothed with sand paper. Brackets are formed by nailing parts *h* to sides. Sides are cut out at top for bracket. Part *j* is nailed to parts *h*. Part *t* is nailed to working platform in position, the legs right side up. Concrete is placed in form to the top, after which piece *k* is set in place and opening *l* filled with concrete. Care should be taken to have tenon *l* and mortise *d* in proper relative position



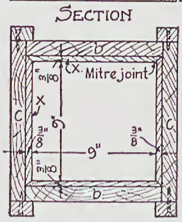
ELEVATION



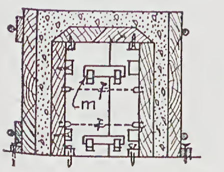
SECTION



DETAIL OF SIDE "C"

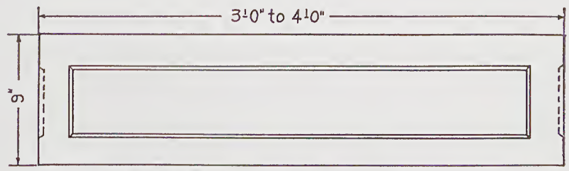


SECTION A-A

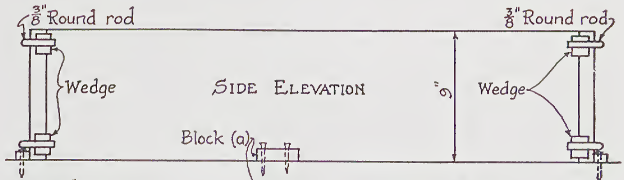


FORM ASSEMBLED SHOWING CONCRETE IN PLACE

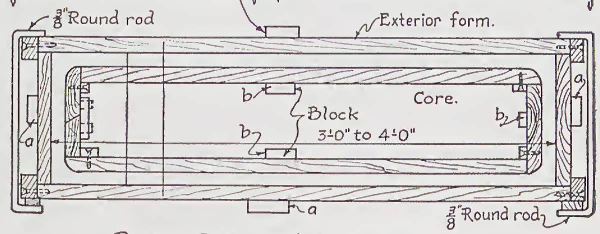
Design with form details for concrete flower-box. Details of making and assembling the core are shown to illustrate the manner in which this box is cast upside down



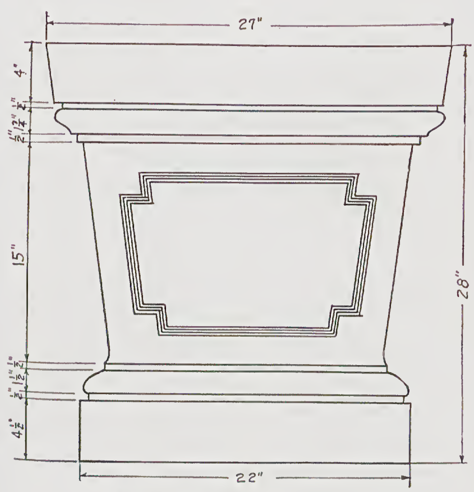
SIMPLE BOX WITH DEPRESSED PANEL



SIDE ELEVATION

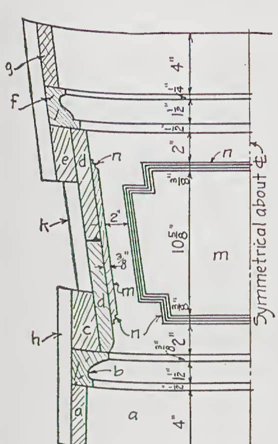


PLAN OF FORM AND CORE ASSEMBLED

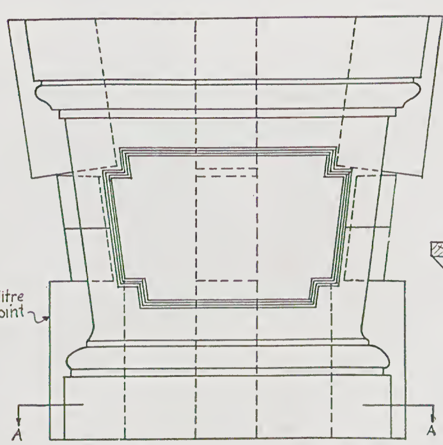


Elevation of Bay Tree Box

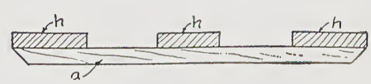
Design for large concrete flower urn or "bay tree" box; showing form details necessary to secure the panel and molding effect illustrated in the finished elevation



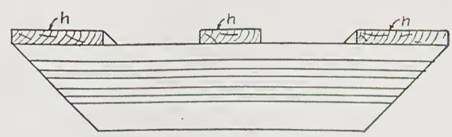
Half Section through Exterior Form



Interior Elevation of one Side of Form



Section on A-A



Top View of one Side of Form
(Four of these required)

Different types of concrete trimstone

A great variety of surface finish is possible through the selection of suitable materials and various combinations of them that the ingenious worker will devise. In small as well as the larger and more ornate products, colored sands and selected aggregates, such as marble chips, granite screenings, mica spar, etc., are used in combination with cement and coloring-matter. See pages 176 and 177, under the head of "Surface Finish of Concrete."

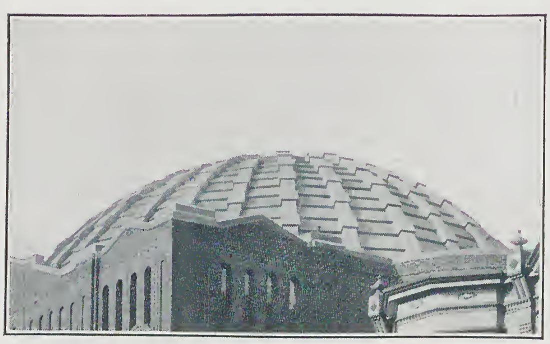
Architectural Trimstone

Concrete trimstone or, as it is sometimes called, architectural trimstone, is the name given to concrete units which are used in some way to ornament, embellish, or perhaps build the entire face of a structure. If used only as ornament, the stone takes the form of trim details of windows and doorways, such as sills and lintels or corner-stones, in combination with ordinary brick or other masonry. Or perhaps medallions are set into the face of a wall, or such architectural details as porch columns, rails, and spindles worked out in precast concrete. Usually designs for such ornamental stone are furnished by the architect, just as he would furnish designs for cutting of natural stone. As a matter of fact, concrete trimstone is now carved by stonecutters just as natural stone is cut.

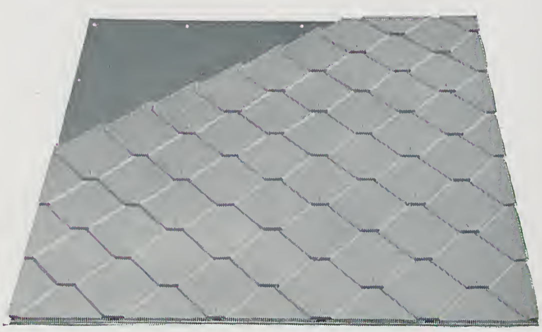
Fire-proof Roofing Materials

The use of fire-proof roofing materials, such as concrete roofing tile, concrete slabs for roofing and domes, and cement asbestos shingles, is becoming more and more prevalent. A steadily increasing number of ordinances compel the use of fire-proof roofing materials. As a consequence, the fire risk in these localities is greatly reduced.

All these products are among the most fire-resistive types of roofing known, and through



Concrete slabs for domed roof make a very interesting treatment



One type of concrete asbestos tile

Concrete asbestos tile is rapidly replacing the old style shingles. It is fireproof and permanent

rapid strides in developing methods of manufacture are more than holding their own in competition with other types.

Concrete Drain Tile

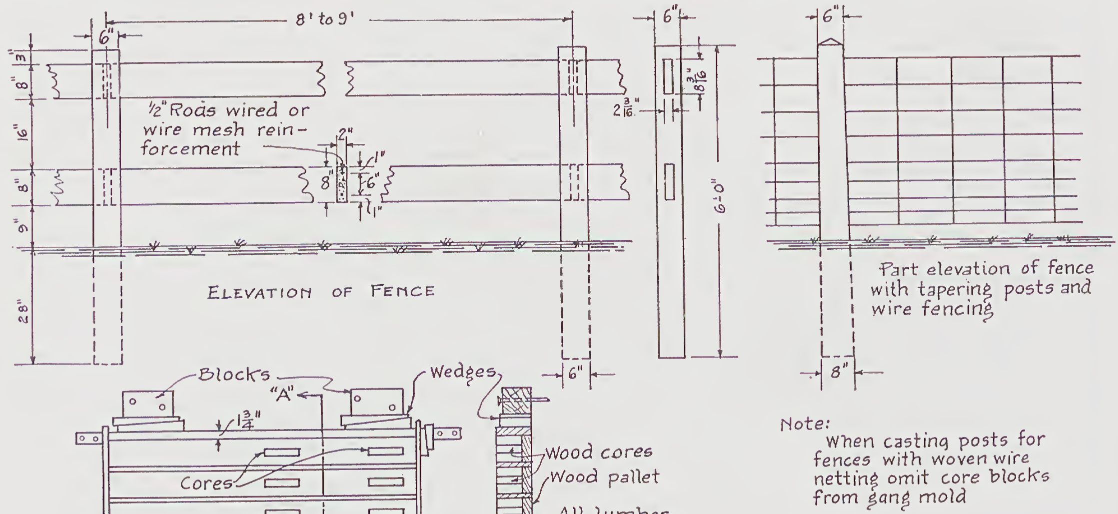
Drain tile, as the name implies, is used to drain wet lands. Concrete drain tile have come into deserved popularity only within comparatively recent years. However, they are by no means a new product, as they were made and used in this country fifty or more years ago, when cement was imported. The general requirements of cement and aggregates used in making drain tile are the same as other concrete products except that the thin wall of concrete tile in the smaller sizes prevents the use of large aggregate. Practically all sizes of concrete pipe and tile 12 inches or less are made by machine. Larger sizes are often made by hand, the concrete being tamped in the forms, which consist of two metal cylinders, one as much smaller than the other as is necessary to provide required wall thickness. In the larger sizes of pipe, such as are used for culverts, reinforcement, usually in the form of mesh, is used.

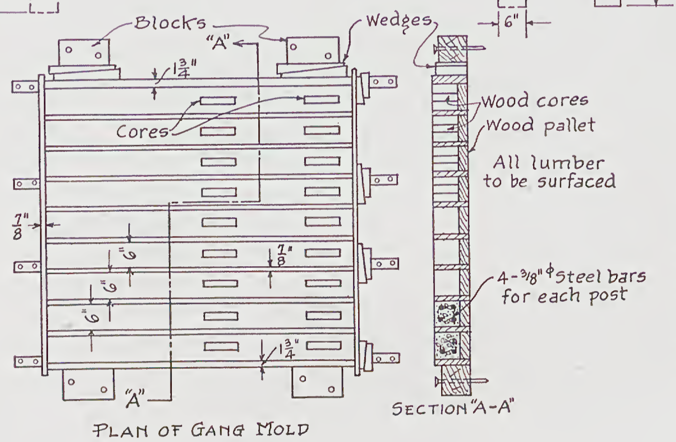
It is characteristic of concrete pipe and tile to be true to form because they are not subjected to any after-treatment that will produce warping or distortion when taken from the mold such as sometimes results in a product that has to be finished by burning in a kiln.

Surface Appearance

A section of concrete pipe or tile that has been made of a concrete mixture having the proper amount of water will show web-like markings on the surface after the form is removed. Markings are caused by water penetrating between the surfaces of contact of concrete and casing. If the tile is made on a machine with a revolving packer head, the outside of the tile will show a web-like marking and the inside will show the marks of the packer head.

Concrete drain tile is made in various shapes and sizes





Fences are sometimes built by stretching fencing wire to concrete posts. In other cases concrete boards or lumber are used to close the space between posts. This drawing shows a gang mold for casting the posts and also the details of the concrete boards when they are used instead of ordinary wire fencing. In the latter case the posts are cast with recesses on opposite sides to receive the ends of the panels

FENCE POST
1 : 2 : 4 Mix

POST

6″ × 6″ × 6′ 0″
.5 × .5 × 6 = 1.50 cu. ft. or .055 cu. yd. of concrete

Material per Post

Lehigh cement	= .083 bbl.
Sand	= .025 cu. yd.
Pebbles	= .049 cu. yd.
4 ⅜″ round bars	= 9 lbs. of steel

FENCE RAILING
1 : 2 : 4 Mix

.17 × .67 × 8 = .912 cu. ft. or .034 cu. yd.

Material per Railing

Lehigh cement	= .051 bbl.
Sand	= .015 cu. yd.
Pebbles	= .030 cu. yd.
2 ½″ round bars	= 10½ lbs. of steel

Concrete Fence Posts

Concrete posts are manufactured in conjunction with other products at regularly established plants and also by the home worker.

There are so many uses for posts of various sizes and shapes about the home, particularly on the farm, that it is not surprising that the home worker tests out his ability as a concrete worker on posts. They are made in various sectional shapes, but square, rectangular, and round are most common.

If one pushes hard against a post at the top, the concrete on the side where the force is applied is in tension, as described under the section discussing the reinforcing of concrete, on page 170. Reinforcement is placed in a concrete post near the outer surfaces because the outer surfaces are the first portion of the post that have to resist this tension or strain. Reinforcement placed at the center is of very little value unless the amount used is relatively excessive. A much smaller quantity correctly placed near the surface is much more effective. If the post section is round, the four rods should be in positions corresponding with the corners of a square. In posts of square, rectangular, or triangular sections the rods should be near each corner. The accompanying tables give various dimensions for posts, also recommendations as to reinforcing. The tables specify round rods, but square twisted rods of the same net sectional area may be used if desired. Several strands of wire twisted to form a single rod are marketed for post reinforcement and are convenient and satisfactory material to use. Barbed wire and

MATERIALS REQUIRED FOR CONCRETE LINE POSTS OF SEVERAL DIMENSIONS

Dimensions			Volume of Post in Cubic Feet	Weight of Post in Pounds	Amount of Reinforcing Metal Required for Each Post	Materials							
						Mortar Mixture 1 : 3			Concrete Mixture 1 : 2 : 3				
						No. Posts Per Barrel Lehigh Cement	For 10 Posts		No. Posts Per Barrel Lehigh Cement	For 10 Posts			
Length	Top	Bottom					Sacks Lehigh Cement	Cu. Ft. Sand		Sacks Lehigh Cement	Cu. Ft. Sand	Cu. Ft. Pebbles or Stone	
7′ 0″	3″x4″	5″x4″	0.8	115	Four	14.0	2.8	8.5	19.5	2.1	4.2	6.2	
8′ 0″	3″x4″	5″x4″	0.9	131	¼″ Round Rods	12.3	3.2	9.7	17.1	2.4	4.7	7.1	
7′ 0″	4″x4″	5″x5″	1.0	143	Four	11.3	3.5	10.6	15.8	2.6	5.1	7.7	
8′ 0″	4″x4″	5″x5″	1.1	163	⅜″ Round Rods	9.9	4.0	12.1	13.8	2.9	5.9	8.8	
7′ 0″	5″x5″	6″x6″	1.5	213	Four	7.6	5.3	15.8	10.6	3.8	7.7	11.6	
8′ 0″	5″x5″	6″x6″	1.7	243	⅜″ Round Rods	6.6	6.0	18.0	9.2	4.4	8.8	13.2	

DIMENSIONS OF CORNER POSTS AND MATERIALS NEEDED

Dimensions		Volume of Posts in Cubic Feet	Weight of Posts in Pounds	Amount of Reinforcing Metal Required	Materials						
					Mortar Mixture 1 : 3			Concrete Mixture 1 : 2 : 3			
					No. Posts Per Barrel Lehigh Cement	For 1 Post		No. Posts Per Barrel Lehigh Cement	For 1 Post		
Length	Size					Sacks Lehigh Cement	Cu. Ft. Sand		Sacks Lehigh Cement	Cu. Ft. Sand	Cu. Ft. Pebbles or Stone
8′ 0″	6″x 6″	2.0	288	Four	5.6	0.7	2.1	7.8	0.5	1.0	1.6
8′ 0″	7″x 7″	2.7	392	½″	4.1	0.95	2.9	5.7	0.7	1.4	2.1
8′ 6″	7″x 7″	2.9	416	Round Rods	3.9	1.0	3.1	5.4	0.8	1.5	2.2
8′ 0″	8″x 8″	3.6	512	Four	3.1	1.3	3.8	4.4	0.9	1.8	2.8
8′ 6″	8″x 8″	3.8	544	⅝″	3.0	1.35	4.0	4.1	1.0	2.0	2.9
9′ 0″	8″x 8″	4.0	575	Round Rods	2.8	1.4	4.3	3.9	1.1	2.1	3.1
8′ 0″	10″x10″	5.6	799	Four	2.0	2.0	5.9	2.8	1.4	2.9	4.3
8′ 6″	10″x10″	5.9	850	¾″	1.9	2.1	6.3	2.6	1.5	3.1	4.6
9′ 0″	10″x10″	6.2	899	Round Rods	1.8	2.2	6.7	2.5	1.6	3.2	4.9
10′ 0″	5″x 5″	1.7	250	Four ⅜″	6.4	0.6	1.9	9.0	0.4	0.9	1.4
12′ 0″	5″x 5″	2.1	300	Round Rods	5.4	0.7	2.2	7.5	0.5	1.1	1.6

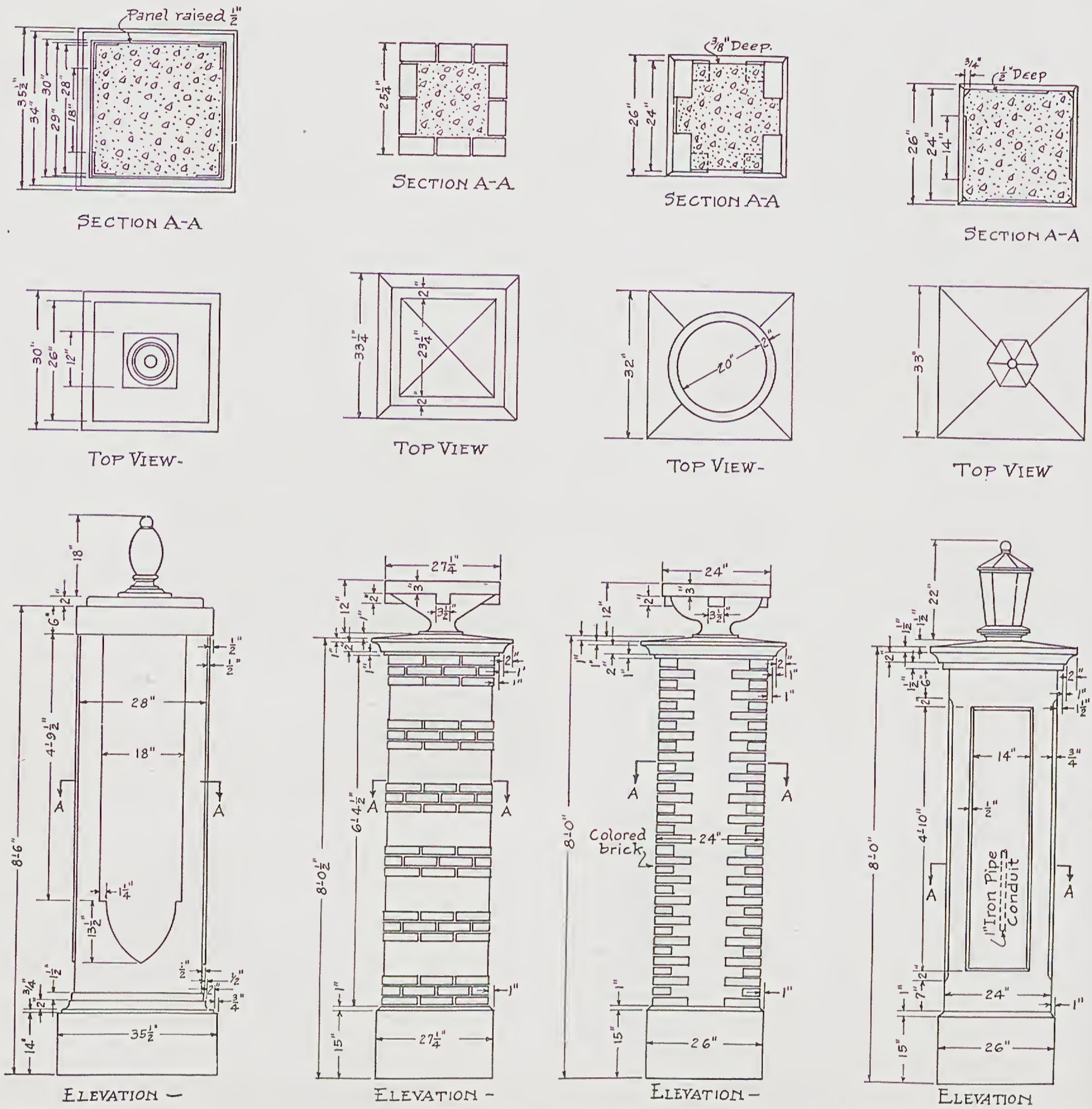
similar scrap metal should not be used because they are not satisfactory reinforcing materials.

There are many types of fence post molds on the market. It is perfectly practicable to make posts in wooden molds, but in general it is best to use one of the commercial types of molds if any considerable quantity of posts is to be made. 1 : 2 : 3 mixture is recommended for concrete fence posts.

Some types of commercial fence post molds are filled by setting the molds vertically and filling from the end. Other types are made with one open side and are filled while lying in a horizontal position. In the type of mold that is filled from the end air-bubbles can be forced out of the concrete by jogging the mold while filling or tapping the mold gently. The posts should not be removed from the molds until they are strong enough to permit handling without cracking. Under favorable conditions the posts may be taken from the mold at the end of twenty-four hours. They should not be up-ended and stood in piles with others until they have lain several days, during which period they should be sprayed frequently or in some other way kept moist so as to hasten curing.

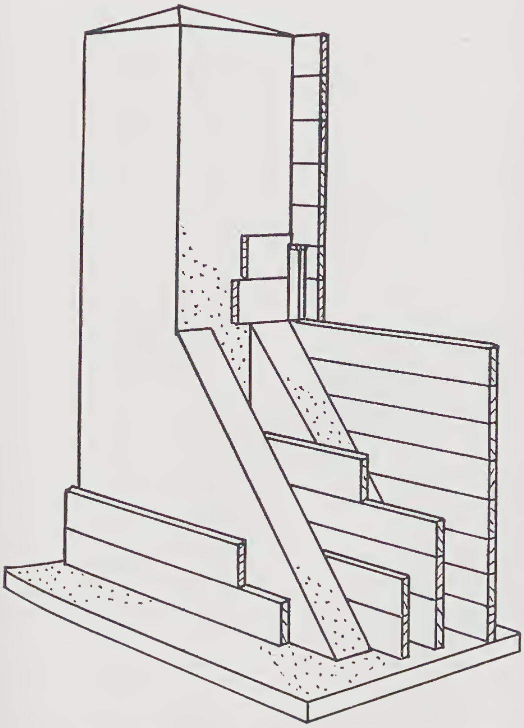
If a wooden mold is used, it should be built so that wedges and blocks only will be necessary to hold all parts assembled, thus making it possible to take the mold apart without hammering and injuring the posts. Concrete fence posts should not be used until they are at least a month old.

Corner and gate posts are often cast in place. Such posts may be used for lighting standards. A numerous variety, both as to design and surface finish, can be made, but great care should be taken in the preparation of the molds.



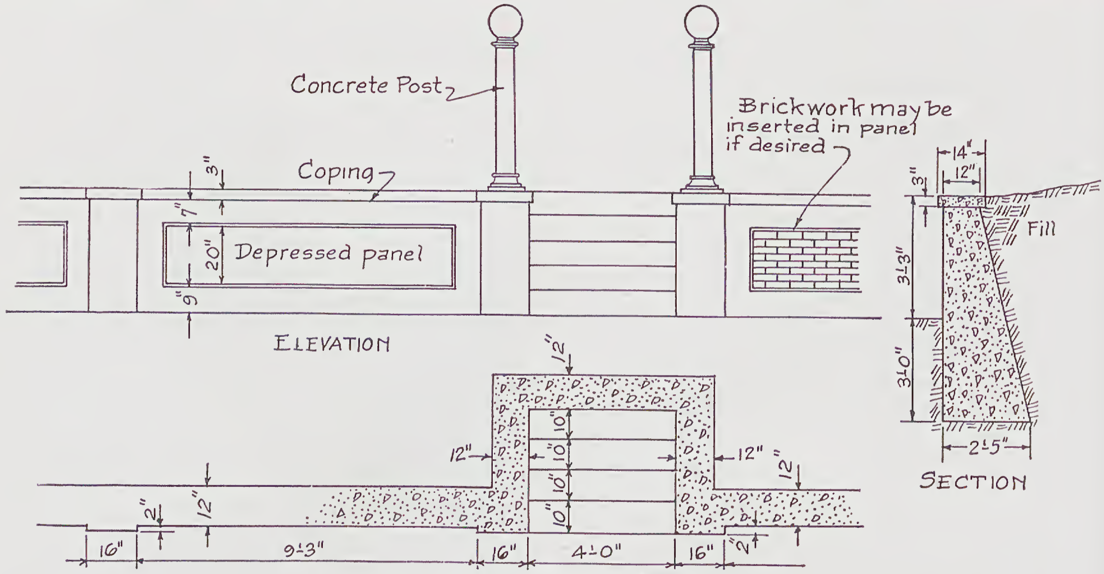
Designs for ornamental posts used for gateways or entranceways. The use of concrete brick is shown in connection with two of the designs as a suggestion for a simple way to secure variety. Very pleasing effects can be secured if the modern faced concrete brick is properly combined with the concrete to secure variation. None of the sections show reinforcement because the designs in these cases are relatively massive. If the posts are intended for use for holding entranceway gates, such as are commonly made of heavy ornamental iron work, ⅝ or ¾ inch round rods should be placed near the corner of each post and about 2 inches from its outer face

Concrete ornamental posts marking entranceways can be made very attractive by using brick in their construction



Illustrations giving suggestions for building heavy monolithic concrete corner post for line fence. Use a 1 : 2 : 4 mixture, letting forms stand without jarring in any way for four days. Hooks can be set in the concrete to allow attachment of a wire fence

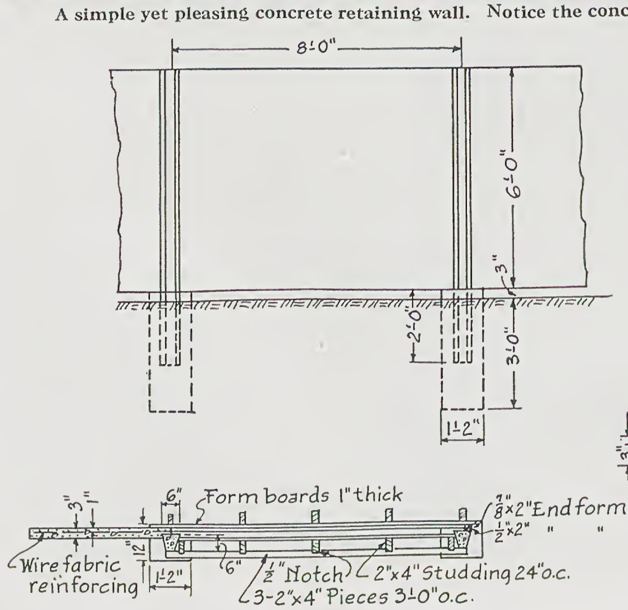
Practical use of corner or gate post

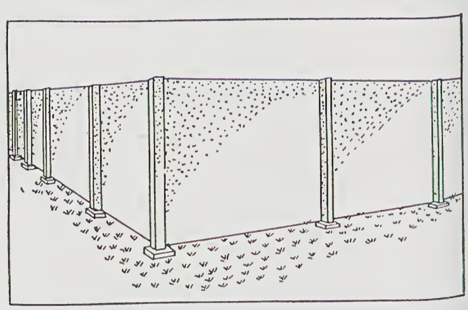


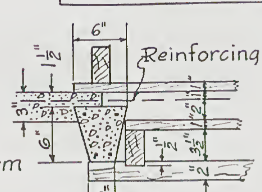
Plan of Wall—Coping Removed

This sketch for concrete retaining wall has been designed to show how steps leading up to the level of the home grounds may be built with the wall. At the same time it suggests by a detail how brick panels may be substituted in place of panel effect secured by depression in the concrete. All retaining walls, no matter what their height, should be designed with a minimum thickness of 12 inches at the top, the thickness toward the base being increased as calculations show necessary to retain the depth of fill back of them. Reinforcement is required

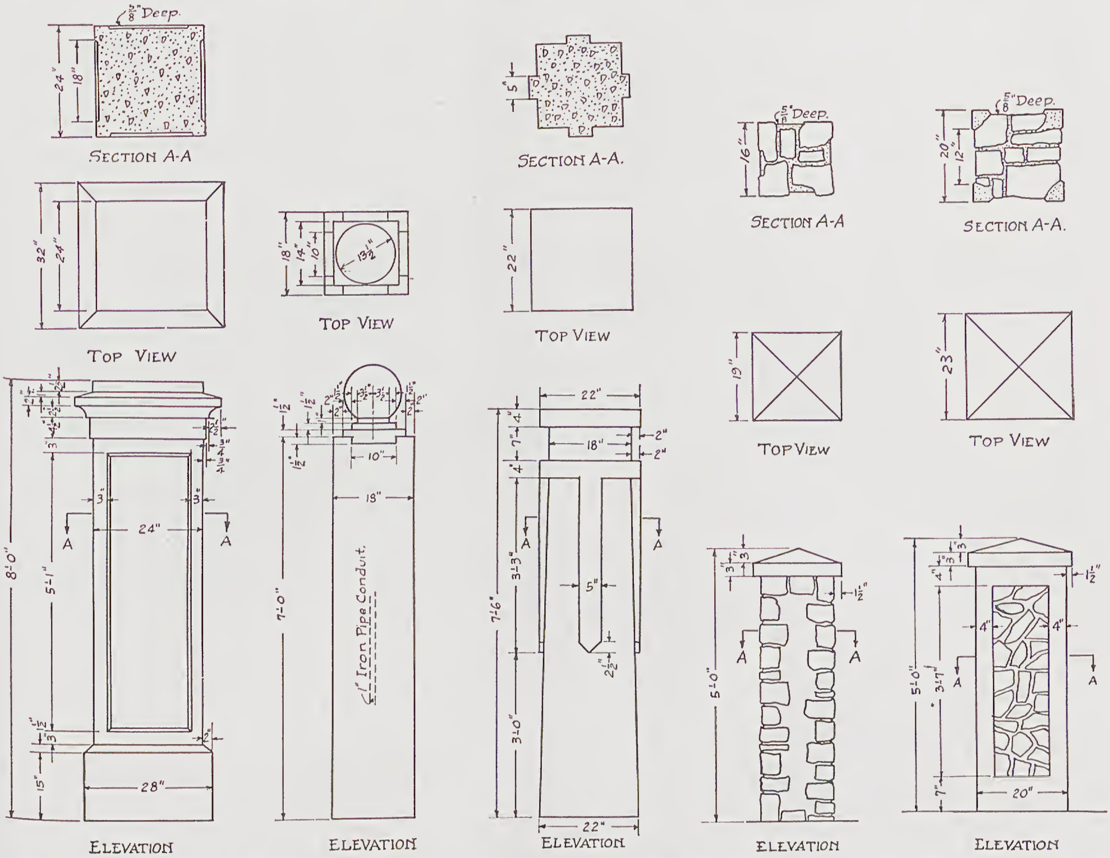
A simple yet pleasing concrete retaining wall. Notice the concrete construction used in both house and garage





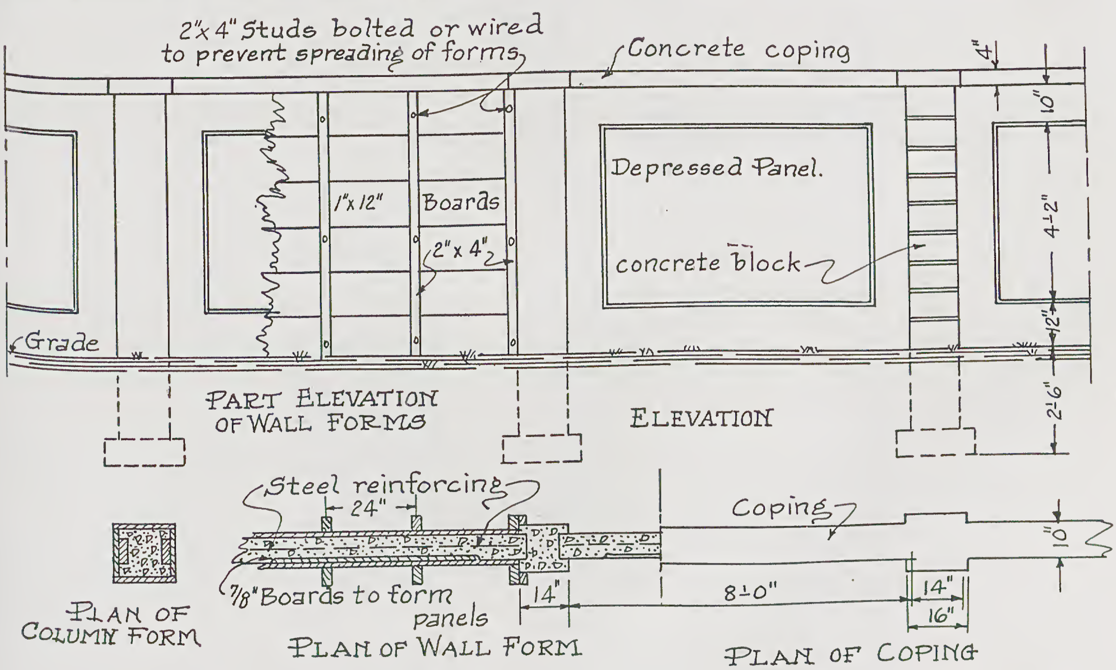


A simple post and panel fence built by first setting the posts and forming the panels by plastering several coats on wire fabric. As is shown in another detail, the panels can be built by setting form sections between posts and depositing concrete in the usual way

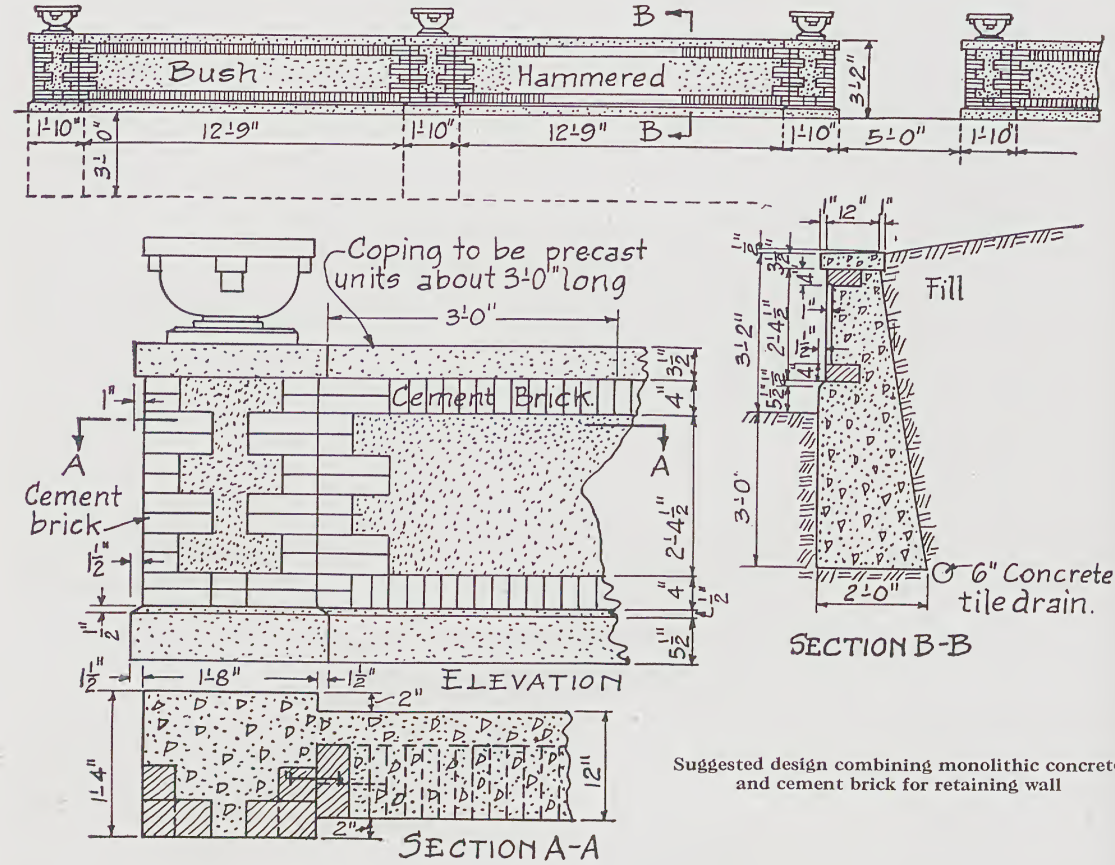


Designs for concrete posts, two of which are commonly called rubble masonry construction. This is done by embedding irregularly shaped stones in a somewhat mushy concrete mixture as the forms are filled

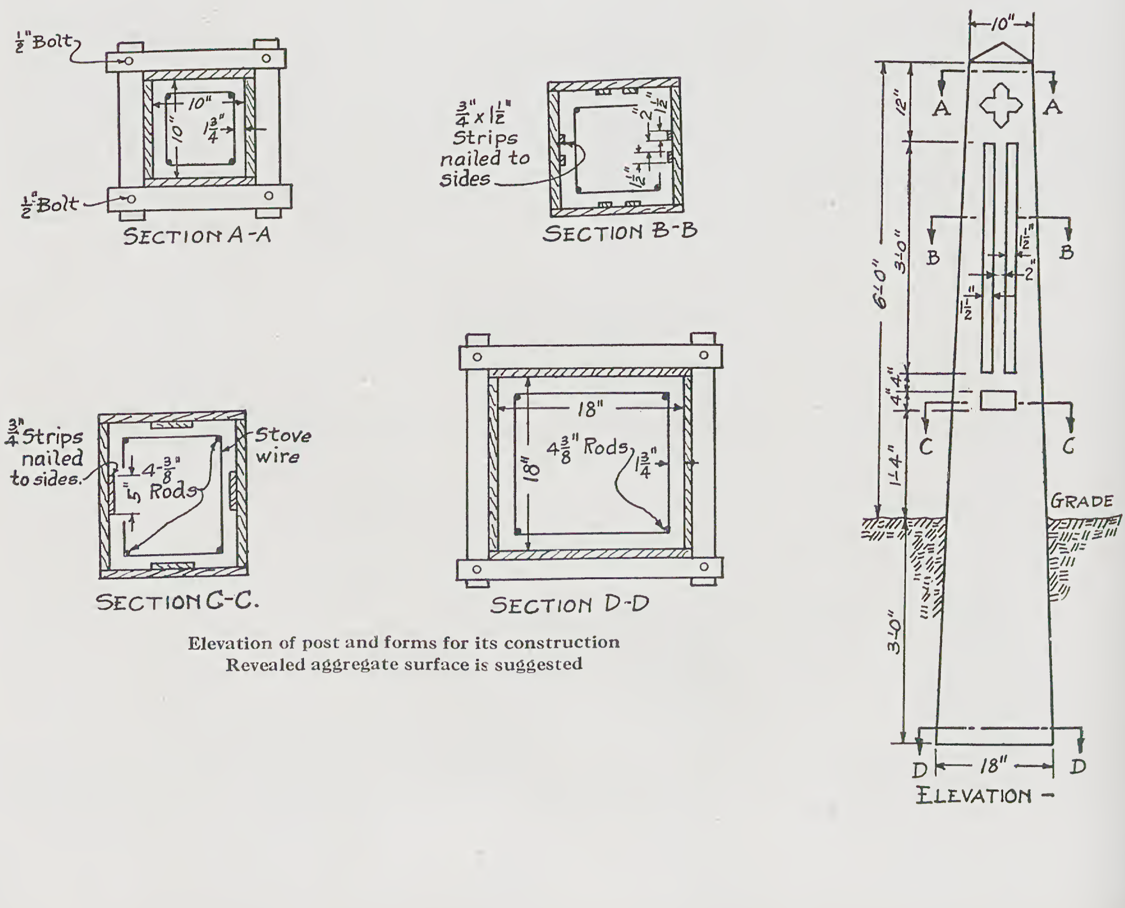
If concrete posts are to be used to carry the load of heavy gates, they should be properly reinforced with four rods as near to their corners as possible. Simple though quite effective ornament for such posts can easily be secured by careful, thoughtful planning of the forms, which involves little more than combining depressed and raised panels and changing the section by simple variations in the use of common wood molding



Form details, together with section and elevation, showing method of constructing simple yet attractive concrete enclosure wall. The posts are precast and recesses provided in two of the other opposite sides to receive the ends of the intermediate panels. Posts can be either monolithic or laid up of concrete block, as one detail of the sketch suggests

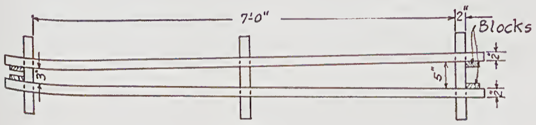


Suggested design combining monolithic concrete and cement brick for retaining wall



Elevation of post and forms for its construction
Revealed aggregate surface is suggested

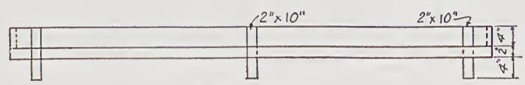
A concrete fence constructed of units made with gang molds



Plan

Bill of Material
1-Piece 8'-0" long, width tapering from 3" to 5" as shown.
2-2"x4"x8'-0"
1-2" Block 3"x4" and 1-2" block 4" to 5".
4-1" Blocks
3-Pieces of 2"x10"

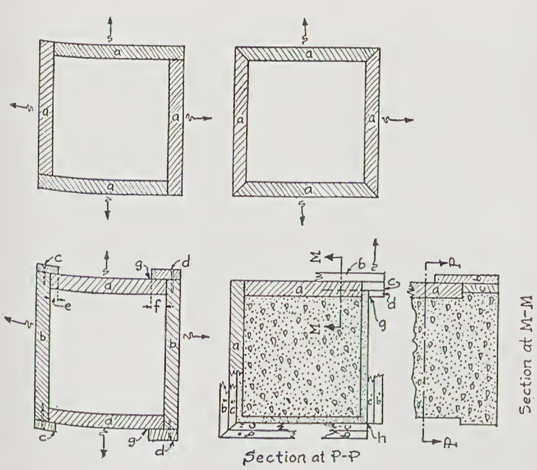
SINGLE FENCE POST MOLD



Elevation.

Mold for single concrete fence post. A gang of molds like this can be made by reversing each particular section as added to the gang. In building a gang mold to cast posts, the bottom is usually omitted and a bottom provided for the entire gang by setting it on a platform while the mold is being filled. The illustration on this page shows another style of posts

The mix used should never be weaker than a 1 : 2 : 4 and should be sufficiently wet, although not sloppy. For at least two days the post should be protected from sun and wind to keep it from drying out. On the fifth day it may be slid gently onto a level surface covered with burlap or straw and sprinkled with water. In two weeks stack outdoors to finish curing



Simple form details showing methods of joining corners. At the upper left hand is a form with square ends made up of the four sides *a*. When the sides are removed from the object in the direction of the arrowheads, there is no possibility of binding

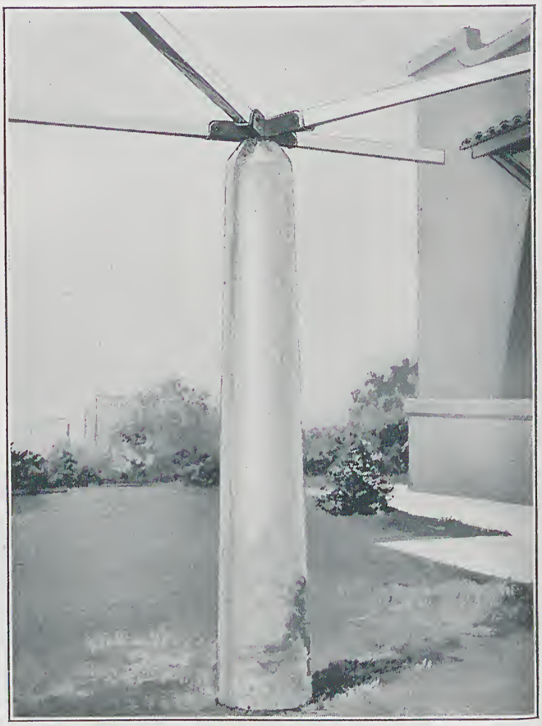
At the upper right hand is a form composed of four sides *a* mitered. This type of form requires a little more care in order that the miter be cut true. The use of forms of this kind is usually confined to concrete objects that have projecting surfaces which would prevent the sides *a* from being withdrawn or removed in the direction of the arrowheads

At the lower left hand corner are various details of a form with squared ends composed of the sides *a* and *b*. Sides *b* have cleats *c* and *d* nailed to their edges. These serve to hold sides *a* securely in position while concrete is being placed. Cleat *c* should not overhang or project beyond side *a* any more than necessary. It should have a good bearing surface on side *a*. This will permit withdrawing side *b* in the direction of the arrowheads with the least amount of binding or sticking due to swelling of the wood when the parts are wet. If the overhang of cleat *c* is as great as shown in cleat *d*, greater difficulty will be experienced in withdrawing side *b* because of this large overhang, as shown at *g* and *f*

At the lower right hand is a form illustrating use of a combination of squared ends and mitered joints. The upper part consists of four sides *a*. The lower portion of the form consists of pieces *c* and *d*, which are nailed together, while the piece *b* is nailed to piece *a*. If mitered joints were not used at the lower portion of this form, it would take the shape as shown in the upper right-hand corner of section *P-P*. The part *d* would have to be nailed to parts *c* and *b* in order to secure the required surface finish at *g*. Such a form when withdrawn in the direction of the arrowhead would bind on the object at *g* and would be difficult to withdraw without injuring the corners of the concrete. This could be overcome by cutting off the ends of the pieces *b* and *c* as shown in the lower right-hand corner of section *P-P* with pieces *b'* and *c'* meeting at the corner and leaving the open space *h*. This arrangement would form a true edge for the concrete product and the forms could be removed without difficulty. Unless the joints at *h* were tight, it would allow water carrying cement to leak out of the form. To prevent this, pieces *b* and *c* are carried out and mitered as shown at *b''* and *c''* at the lower left-hand corner of section *P-P*

Mitered joints should be used in every case where there is even a slight projection beyond any one surface of the concrete object

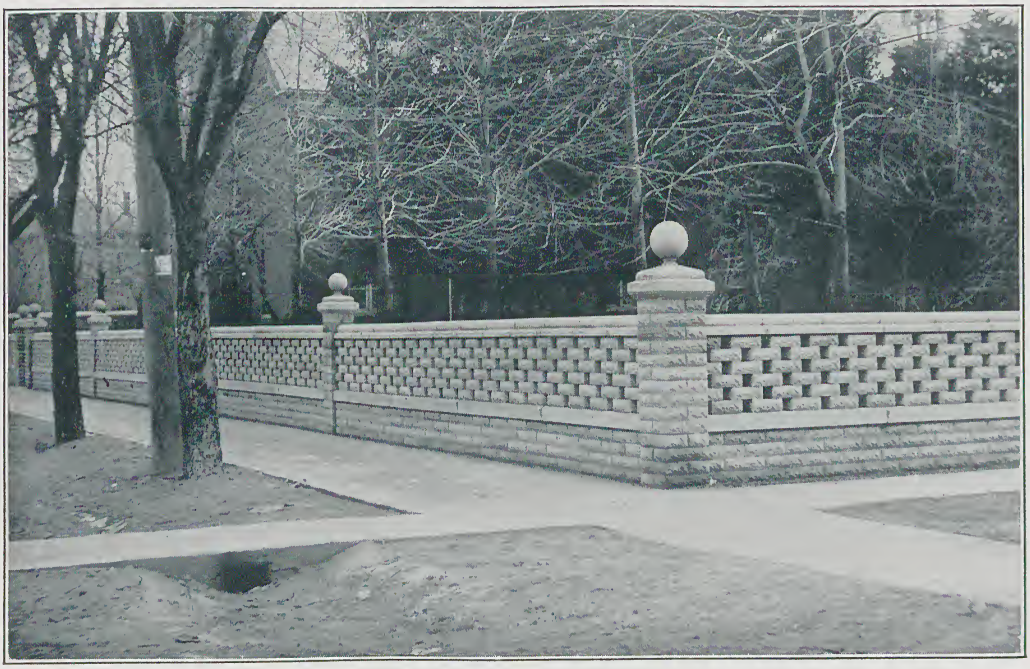
Placing concrete in cylindric steel form for gate-post. This form is a piece of old smokestack, and the intention is to leave it in place after it has been filled. One of the men is setting bolts to provide fastenings for the gate



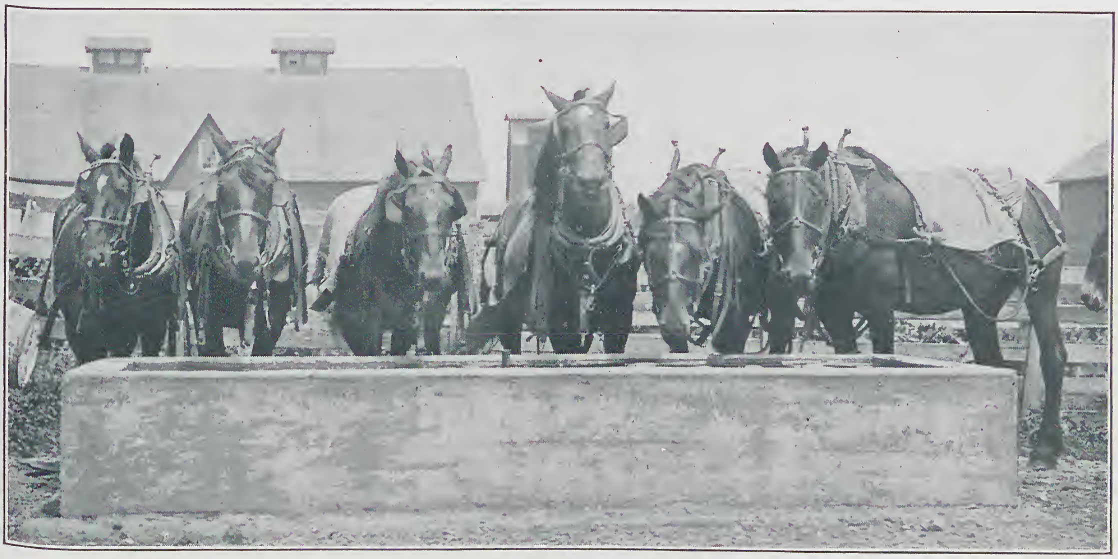
A clothespole is made in exactly the same manner as a gate-post, either round or square, and built to a convenient height. The wooden hangers can be taken down to prevent them from becoming dirty or weatherbeaten

There are many other concrete units which can be placed under the head of "Concrete Products." The details for those already shown and described can be applied readily to practically all of the others.

Study "Fundamental Principles," on pages 153 to 185, which contains all of the necessary preliminary information for making concrete units, before proceeding with the plans or the designs shown.



Concrete block enclosure walls can be made attractive



A clean water supply and healthy stock go together

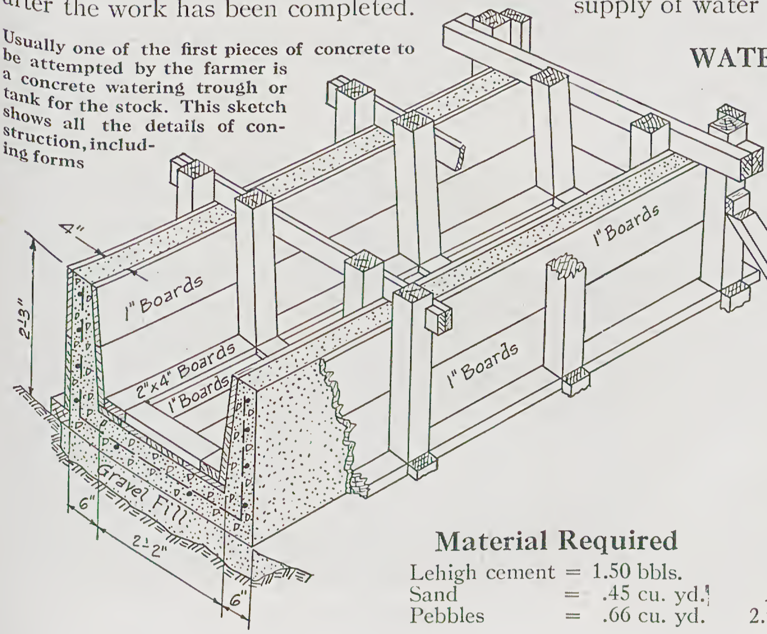
Troughs, Tanks, and Bins

ONE of the largest fields of usefulness for concrete is in building tanks, troughs, bins, cisterns, or similar containers intended to hold liquids and many dry materials, such as sand, gravel, ore, coal, etc. Watertightness is the prime essential of any structure intended to hold liquid. It is very important, therefore, that concrete for such structures be made with greater care in selecting, proportioning, mixing, and placing than would be necessary with other classes of work. It is easier to make concrete watertight at the time of construction than it is to make leaky concrete watertight after the work has been completed.

Hog wallows, dipping vats, and manure pits properly fall into the classification of tanks.

Tanks, troughs, bins, and other similar structures may be square, oblong, or round. Some are built below ground, partly above ground, or entirely above ground, and in the last case are sometimes considerably elevated. This is true of water towers, standpipes, and supply tanks that are to hold water to be delivered under pressure. Water tanks for domestic farm supply are often built on top of concrete silos. This makes it possible to have running water in any farm building and a supply of water under pressure in case of fire.

Usually one of the first pieces of concrete to be attempted by the farmer is a concrete watering trough or tank for the stock. This sketch shows all the details of construction, including forms



WATERING TROUGH
1 : 2 : 3 Mix

SIDES

2.25
.42
———
450
900
———
.9450
2
———
1.8900 sq. ft.

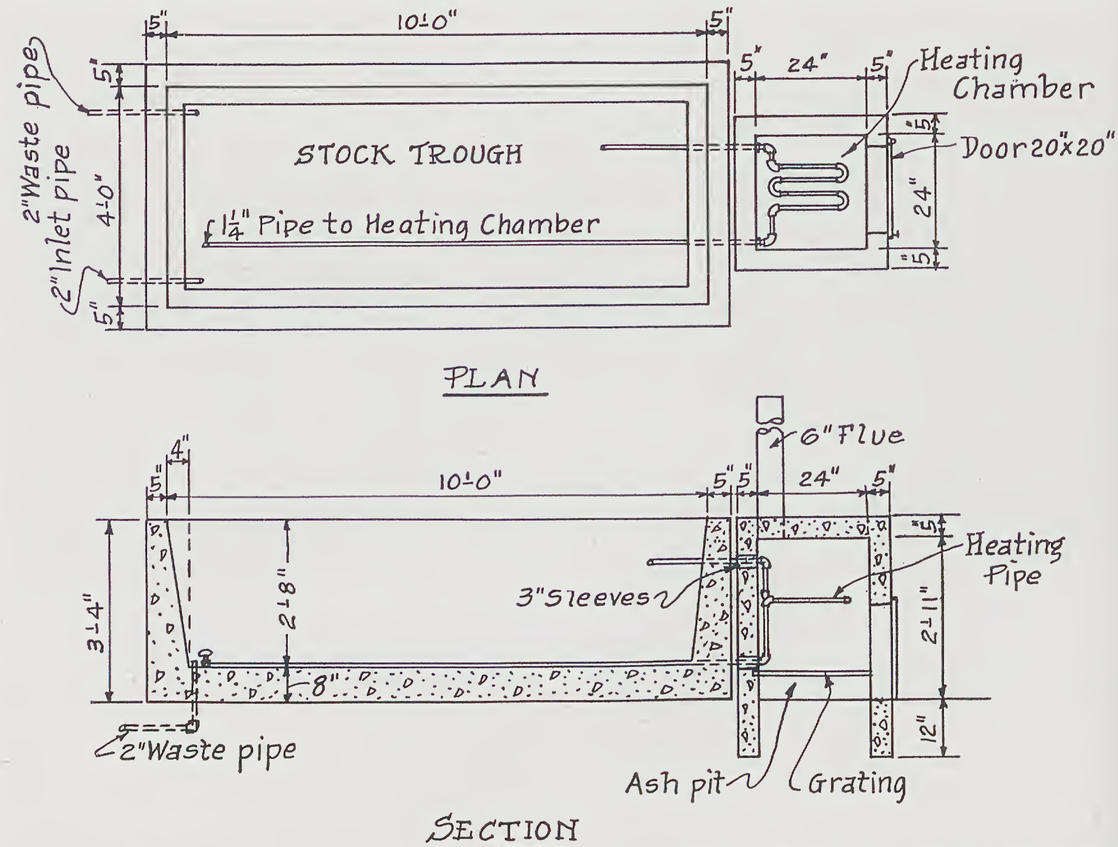
BOTTOM

2.17
.5
———
1.085 sq. ft. 1.89 sq. ft.
1.09 sq. ft.
———
2.98 sq. ft. in cross-section

Assume length of 8 feet for trough:
$2.98 \times 8 = 23.84$ cu. ft. or .86 cu. yd.

Material Required

Lehigh cement	=	1.50 bbls.
Sand	=	.45 cu. yd.
Pebbles	=	.66 cu. yd.



This sketch suggests a method of building a tank heater of concrete to warm the contents of an ordinary stock watering trough or tank such as would be placed in the barnyard

In extremely cold weather stock cannot satisfy their thirst from the watering tank where they have to crack the ice to get a drink. They do not want warm water, but they do not want water so cold as to prevent them from drinking all they require.

The heating compartment is essentially a small stove in which is built a radiator coil that is connected with the tank and permits circulating warm water as heated in the coil. The intake for the radiator is a pipe line lying along the bottom of the tank, and the discharge a short piece from the radiator entering the tank near its upper part. The particular precaution to observe in building a heating compartment like this is to use fire-resistive aggregates or preferably make the inside form for the heating chamber of sheet steel or fire brick. The concrete must be well reinforced and particular pains taken to make watertight connections between heating chamber and the concrete tank.

Square or oblong tanks of various kinds are easier for the home worker to build because form construction is simpler than for circular shapes. Where tanks are used for commercial or industrial purposes, special metal forms similar to those used in building silos, circular coal pockets, and grain elevators are generally used. Small tanks or troughs can very readily be built by the ordinary home worker. In planning to build a trough or tank such as would be used for stock watering, concreting should be continuous until the work has been finished. This is the surest way to prevent construction seams that might cause leakage. The pressure exerted by the contents makes it

A small drinking trough which can be made by any one handy with tools

A watering trough with a paved area around it

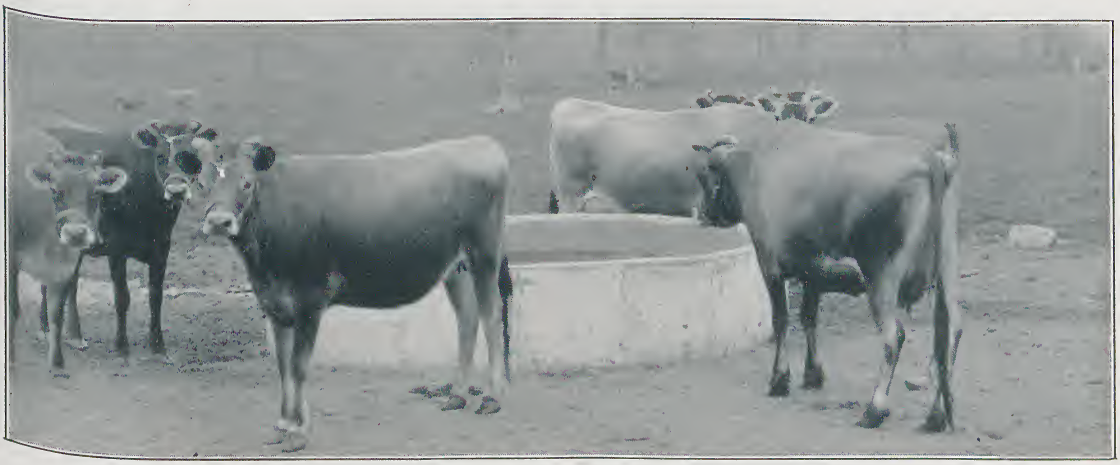
necessary to reinforce tanks and bins. Each structure of this type is a problem in itself, as will be seen by referring to various illustrations which show different reinforcement requirements.

For small tanks, either steel rods or mesh fabric may be used. If fabric is used instead of rods, be careful to see that the net quantity of steel in the mesh corresponds to the quantity of steel called for in the designs.

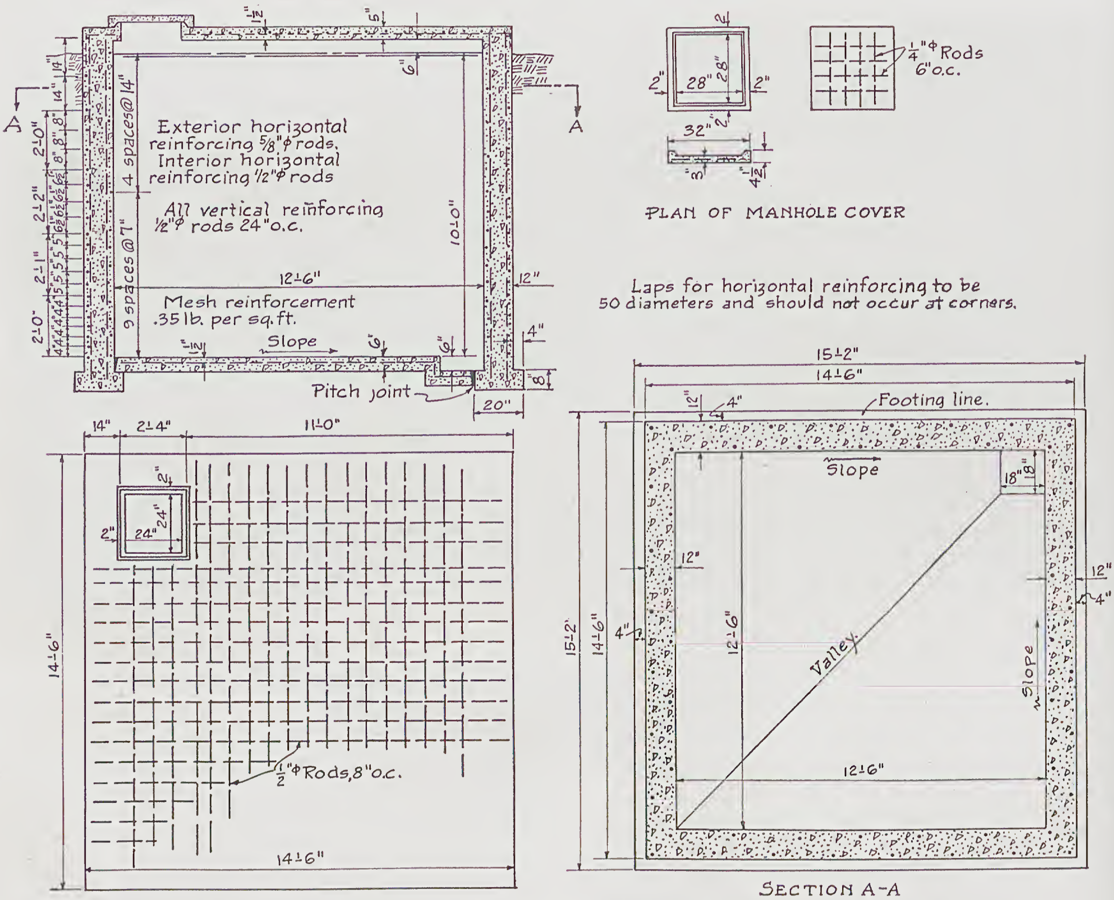
In all tanks and bins both vertical and horizontal reinforcement is required. Corner rods should be provided.

For small open troughs and tanks, such as are used for watering cattle in the barnyard or pasture lot, it is necessary to provide against the pressure of ice by sloping or battering the inside wall face of the tank. This slope will ease the pressure of ice due to freezing of water, and will relieve some of the bursting pressure and keep it from injuring the tank.

The consistence of concrete should be what may best be described as jelly-like. Spading between forms and against form faces must be thorough in order to produce a dense concrete. Only in this way can watertightness be actually assured. Forms should not be removed until several days after the last concrete has been placed, and during this time the work should be kept covered with wet hay or straw, or in some other way to keep the concrete from drying out. The work should in no way be disturbed until the concrete is hard. A failure to spade the concrete thoroughly may result in irregularities in the finished surface. If this condition is found when the



A circular tank is one of the best types of watering troughs



Reinforced concrete tank for holding liquids. Can be constructed either above or underground

TANK—Capacity = 11,700 Gallons. 1 : 2 : 4 Mix

Footing	=	1.67 ×	.67 ×	61	=	68.0 cu. ft.
Side walls	=	11 ×	1 ×	60	=	660.0 cu. ft.
Bottom	=	.5 ×	12.5 ×	12.5	=	78.0 cu. ft.
Top	=	.42 ×	12.5 ×	12.5	=	65.5 cu. ft.
						871.5 cu. ft. or 32.3 cu. yds. of concrete

Material Required

Lehigh cement = 48 bbls. Sand = 15 cu. yds.
Pebbles = 30 cu. yds.

Reinforcement

Exterior	=	1,260′ 5/8″ round rods	= 1,310 lbs.
Interior	=	840′ 1/2″ " "	= 1,198 lbs. (Interior, Vertical, Roof)
Vertical	=	360′ 1/2″ " "	
Roof	=	588′ 1/2″ " "	
Bottom	=	55 lbs. of mesh reinf.	
Manhole cover	=	24′ of 1/4″ round rods	= 4 lbs.
			2,512 lbs. of bars
			55 lbs. of mesh

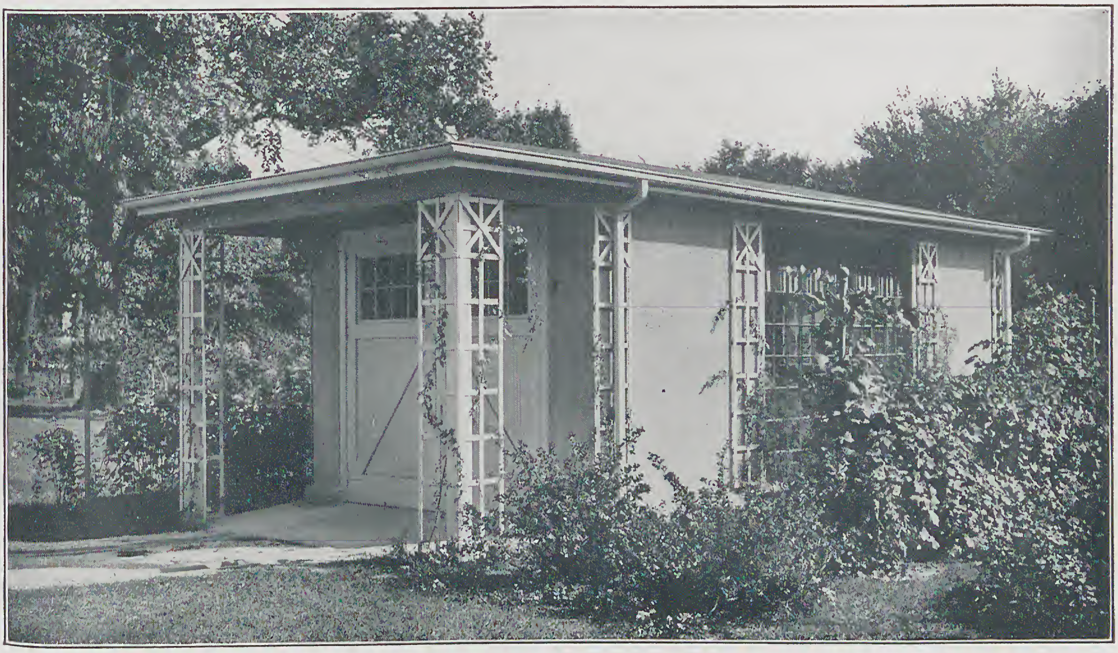
forms are removed, patching should be done with a cement mortar consisting of 1 part cement and 2 parts sand.

Provision must be made for water inlet and outlet at the time forms are set. An outlet is as necessary as an inlet, because tanks must be cleaned occasionally, and the easiest way to flush them is through an outlet provided for that purpose. By using a double valve connection the inlet and outlet can be combined into one fitting, which may be built into the floor when the first concrete is placed.

Small troughs or trays are convenient in feeding poultry and hogs. These can be cast upside down in very simple forms by first setting up a core and around this building a frame so that the distance between frame and core surface will be equal to the required thickness of trough walls.

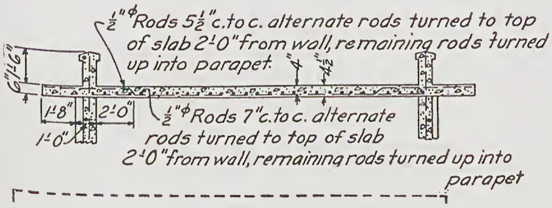
In the table of arbitrary mixtures given on page 157 the range of aggregate size for certain classes of tanks and bins will be found.

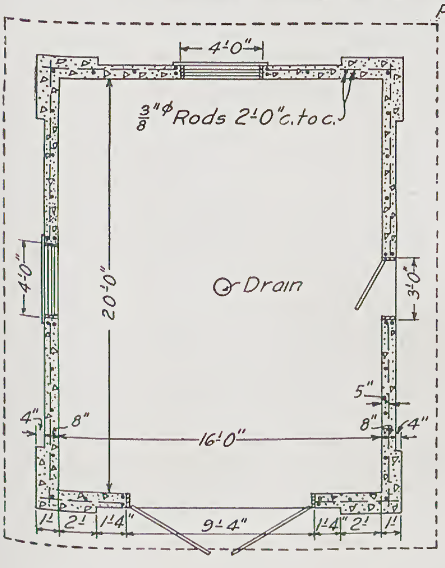
In the pasture and barnyard cattle will soon work a mud hole in the vicinity of the watering trough unless a paved area is provided around the tank. The details of floor pavement and walk construction which apply in this case are to be found on pages 64 to 68.

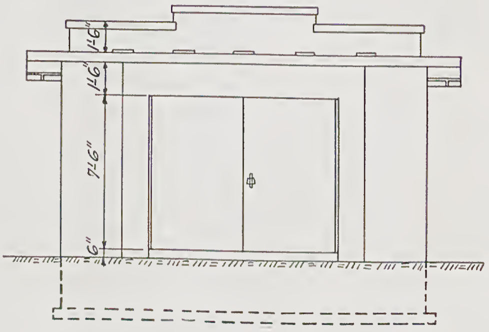


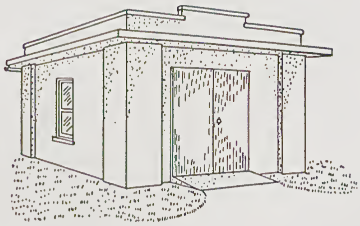
Concrete Garages

A GARAGE should be made large enough to provide plenty of room so that there will be ample space to work around the car. There should be also room for a work bench and lockers for certain accessories. If any considerable quantity of gasoline is to be kept









Design for monolithic concrete garage, with details of roof construction

GARAGE—1 : 2 : 4 Mix

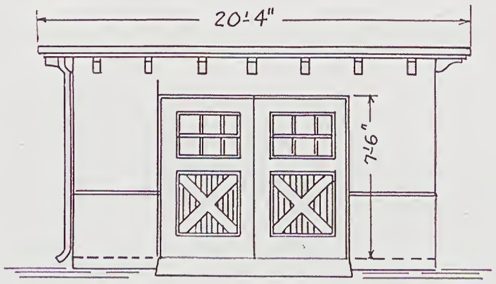
Walls	= 744 cu. ft.
Plaster	= 75 cu. ft.
Floor	= 134 cu. ft.
Roof	= 195 cu. ft.
	1,148 cu. ft. or 43 cu. yds.

Material Required

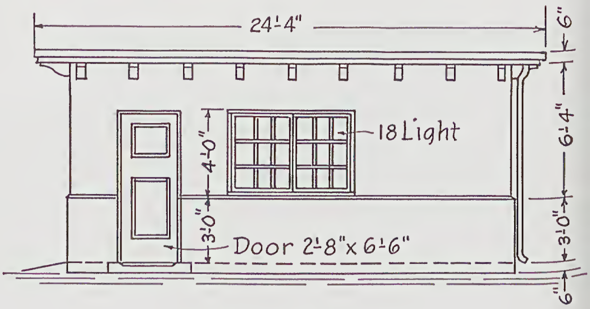
Lehigh cement	= 65 bbls.
Sand	= 20 cu. yds.
Pebbles	= 39 cu. yds.

Reinforcement

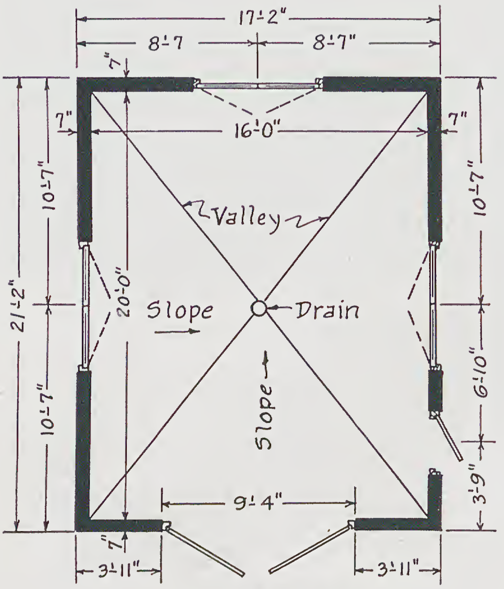
WALLS:	⅜" round rods = 820 lin. ft. or	312 lbs.
ROOF:	½" round rods = 1,998 lin. ft. or	1,335 lbs.
		1,647 lbs. of steel



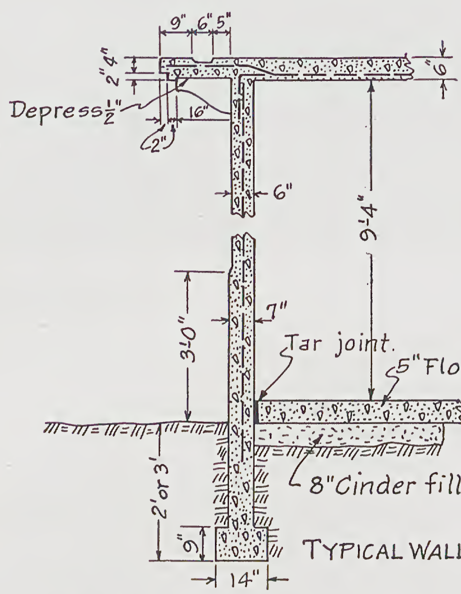
FRONT ELEVATION



SIDE ELEVATION

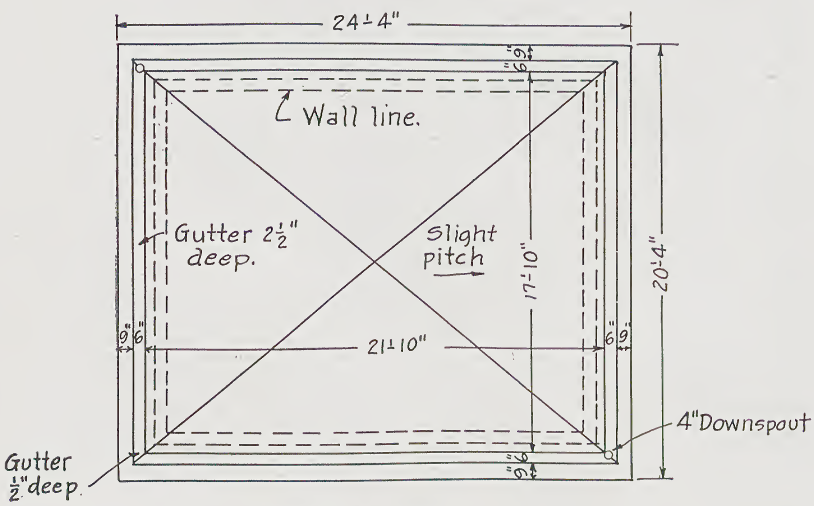


FLOOR PLAN

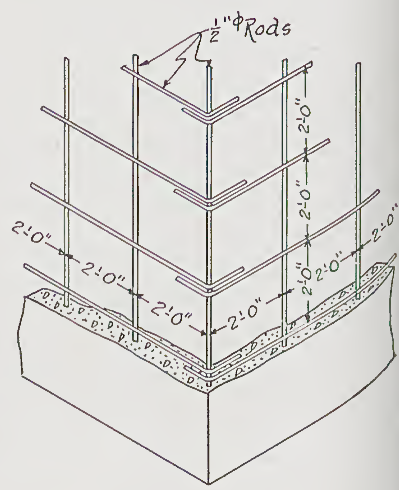


TYPICAL WALL SECTION

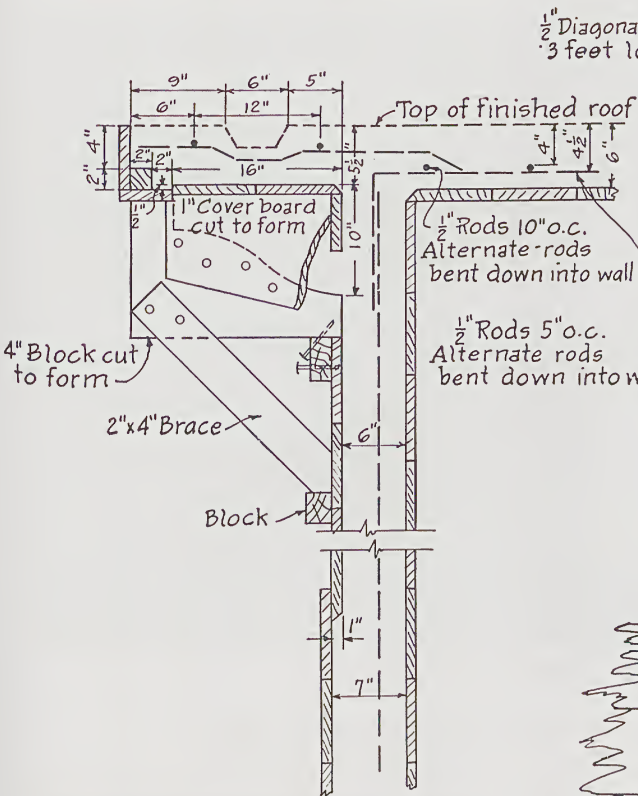
Design for reinforced monolithic concrete garage. Note the manner in which reinforcement should be placed at corners of structure and around openings of windows and doorways. Form details are shown for a section through the wall near its top where provision must be made for casting the cornice and proper placement of reinforcement in cornice and roof. In the details showing corner reinforcement, although actual lapping of horizontal rods is at the corner, the ends of these rods extend around the corner and into the two sides far enough to insure full effectiveness of such reinforcement



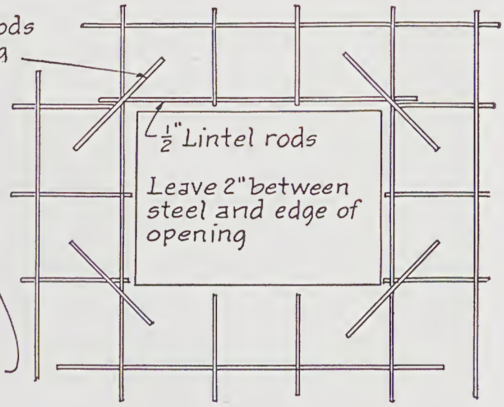
ROOF PLAN



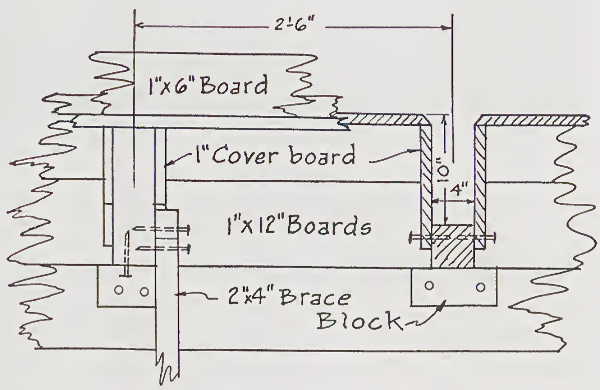
VIEW OF CORNER SHOWING REINFORCEMENT



TYPICAL SECTION THRU WALL FORM



ARRANGEMENT REINFORCING DOOR AND WINDOW OPENINGS



SIDE ELEVATION OF CORNICE FORM SHOWING SECTION THRU BRACKET FORM

GARAGE

1 : 2 : 4 Mix

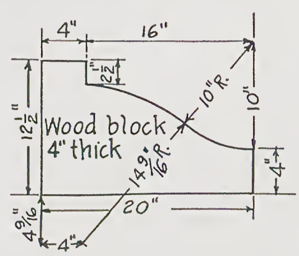
Walls and footing	598.40 cu. ft.
Openings deducted	68.40 " "
	530.00 " "
Roof and floor	404.00 " "
Total	934.00 cu. ft. = 34.59 cu. yds.

Material Required

Lehigh cement	= 50 bbls.
Sand	= 15 cu. yds.
Pebbles	= 28 cu. yds.

Reinforcing

3100 lin. ft. of ½" rods
Tie wire



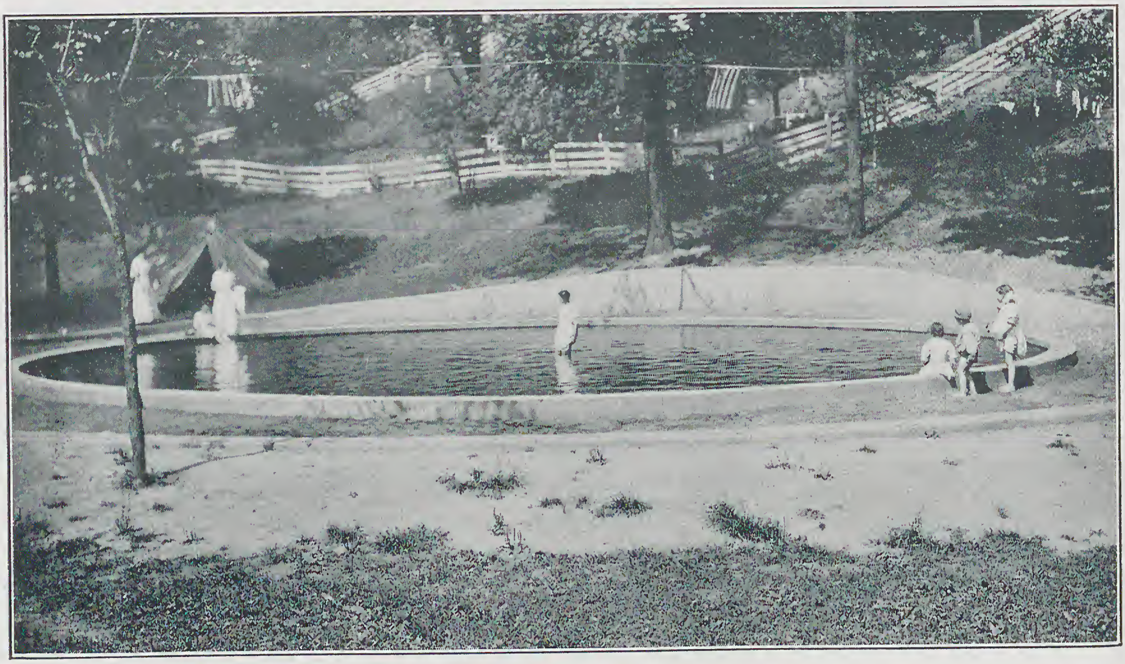
DETAIL OF BRACKET FORM

on the place this should be stored in an underground tank of steel cased in six inches of concrete. Arrangements for filling the tank should be entirely outside of the garage. A pump with suitable connections to draw gasoline from the tank may be inside the garage. A sketch on page 96, under "Troughs, Tanks, and Bins," suggests an ideal treatment for an enclosure tank for storage of inflammables.

Like other buildings of its kind, the garage should have a concrete floor which should be sloped to a drain, preferably trapped at the center so that wash-water will be led away to a sewer or some other outlet.

The information and tables under "Roofs," on pages 106 and 107, will help in the construction of the roof. Concrete asbestos roofing tile is becoming more and more popular because it is fire resistant, serviceable, and permanent.

Several designs and photographic illustrations of concrete garages on pages 6 and 7 show that such structures can be satisfactorily and attractively built of either monolithic concrete or concrete block.

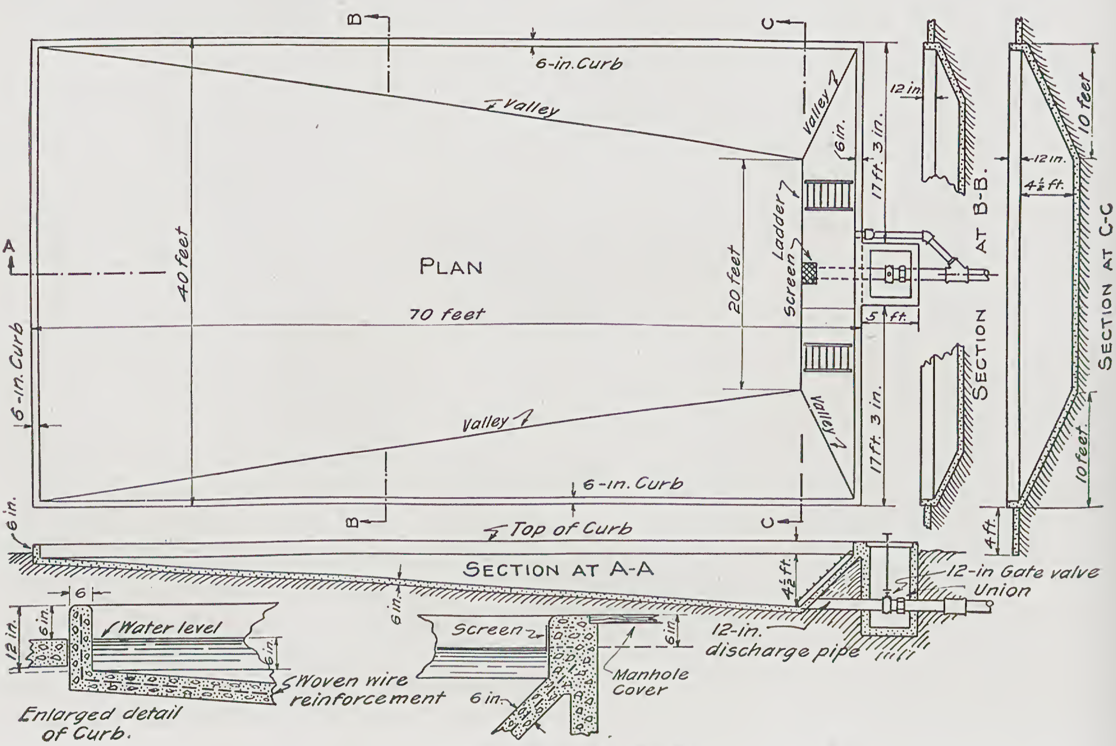


A concrete wading pool is a pleasure spot for children

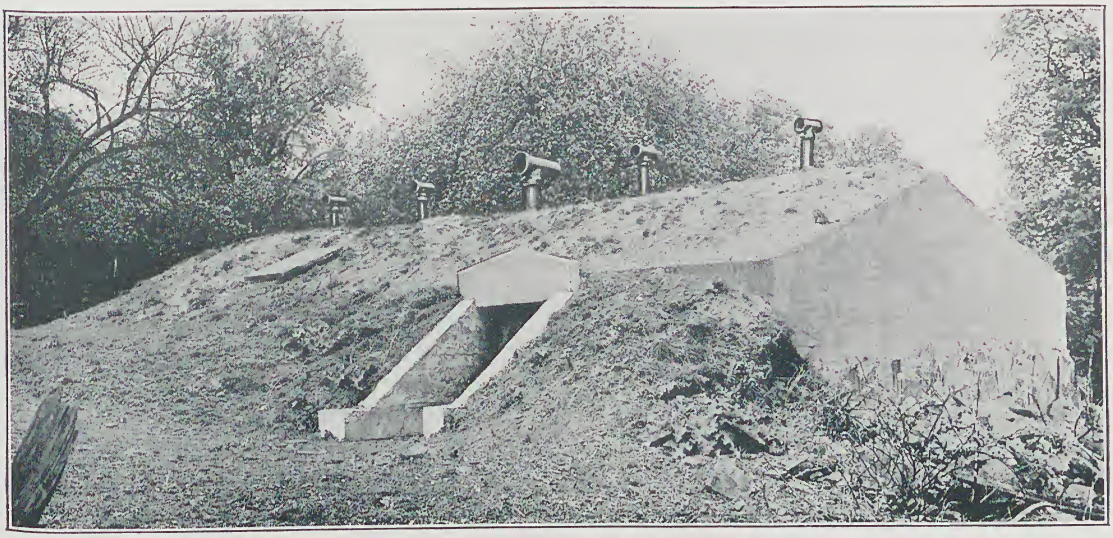
Swimming and Wading Pools

SWIMMING and wading pools of concrete belong in the same class of structures as concrete tanks. It is necessary that a swimming pool be designed with particular reference to the water pressure the concrete must resist when the pool is full and the earth pressure to be encountered when the pool is empty.

Many communities have found that a trifling service charge is justified for the use of the public pool.



Design for small concrete swimming pool



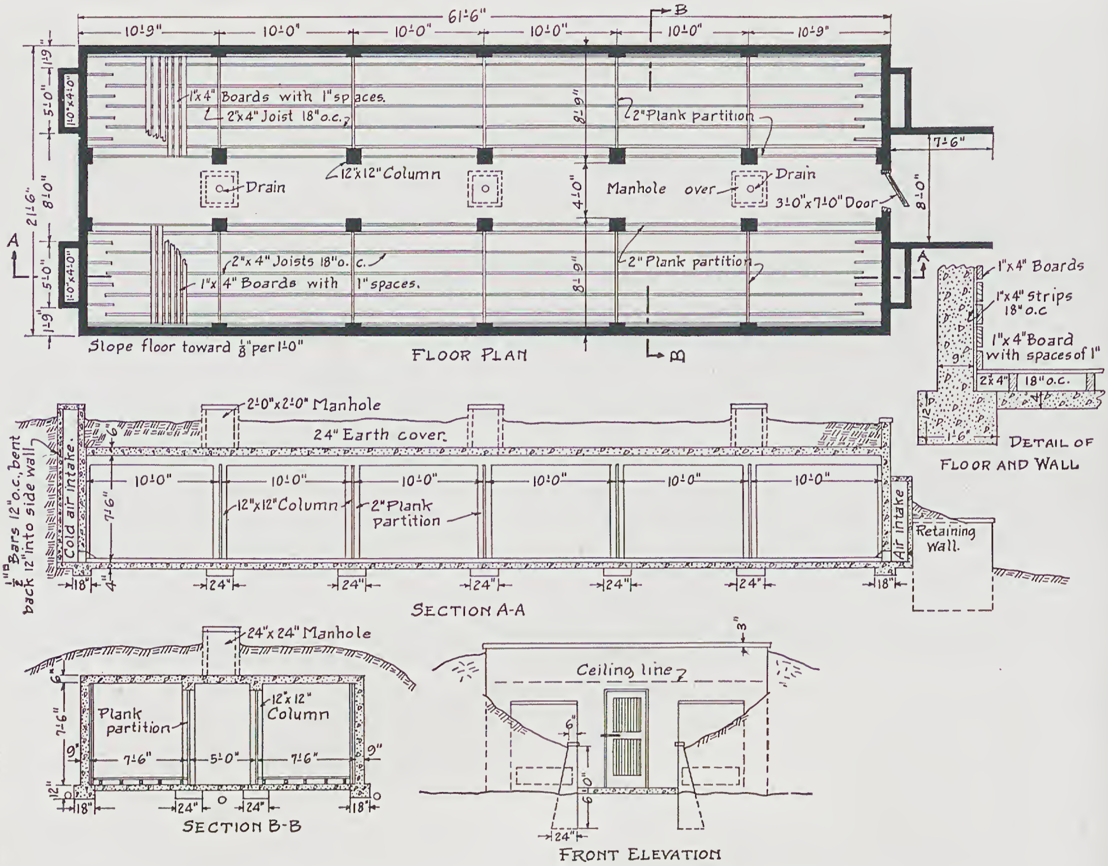
Monolithic storage cellar with ventilators

Fruit and Vegetable Storage Cellars

MODERN root, fruit, or vegetable storage cellars are best built of concrete because, in a properly designed concrete structure, ventilation and regulation of moisture and temperature can be accomplished with less difficulty. For best results storage structures of this kind should be at least partly under ground in order to protect against extreme outside temperature changes. A hillside location is most desirable because less earth need be handled in excavating.

Not every farm has the same needs with respect to storage requirements, and it is for this reason that no one design is likely to meet all

Concrete cyclone cellars are necessary adjuncts to schools and public buildings in some parts of the country

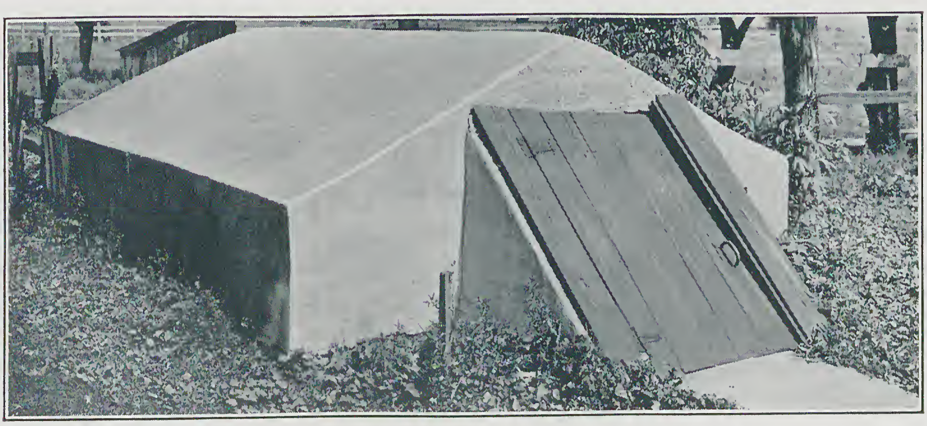


This design for storage cellar for fruit and vegetables consists of a number of bays or units throughout its length. Size can be varied at will by omitting some of the units or increasing length and capacity by adding others. A side-hill location is to be preferred, where possible, for a structure of this kind. It reduces the volume of excavation required, while at the same time making it easier partly or wholly to cover the structure with earth, thus assisting in keeping the indoor temperature more nearly constant

individual needs. Typical storage structures for fruit or vegetables are shown. Capacity may be expanded for the design shown above by the adding of unit sections, provided width is not varied.

An important detail of storage cellar construction for fruits or vegetables is suitable ventilation, to maintain proper atmospheric control to keep fruit in prime condition, and to prevent excessive condensation of moisture on structure walls due to the influence of sudden changes in exterior temperature.

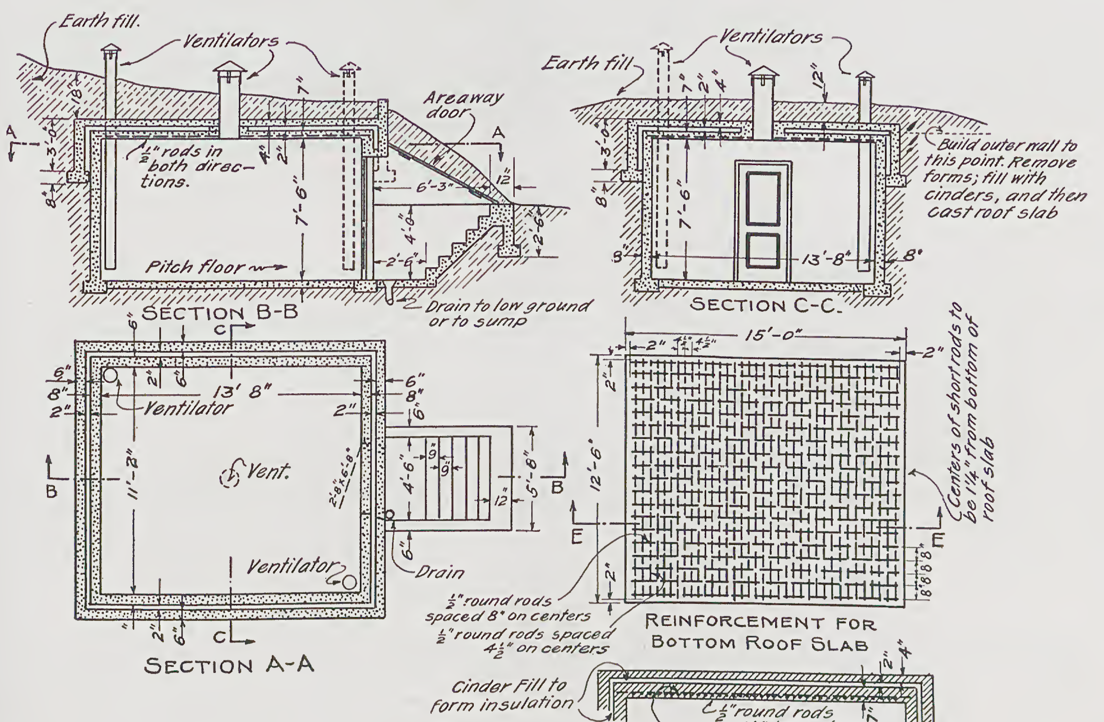
Storage cellars may be built either monolithic or of concrete block. Sometimes the latter

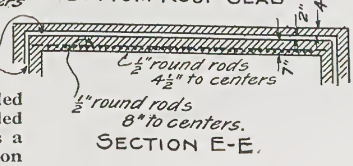


A small monolithic covered storage cellar with concrete entranceway and peaked roof

type of construction is particularly advantageous because of the insulation introduced in the wall through the cells in the block. If similar insulation is desired in a monolithic concrete cellar, it may be secured by laying up a wall of hollow block or hollow tile on the inside as sort of a veneer. During cool evenings manhole and cold-air intake covers should be manipulated so as to permit cold air to pass down into the cellar and circulate throughout it. In extremely cold weather these openings may have to be closed, and in more extreme cases a moderate amount of heat may have to be maintained in the cellar in order to keep the temperature from getting below freezing during the protracted cold spells.

Similar structures are also used in some parts of the country for cyclone cellars.





Small fruit and vegetable storage cellar with flat roof fully detailed to permit home construction. The double roof slab provides added insulation from changing temperatures. Can be adapted as a small ice house by extending the double wall insulated construction down to the footings and building the house at ground level so that ice will not have to be carried up the steps. A drain should be placed at the center of the floor inside to take care of meltage water. Complete design for roof reinforcement is shown

STORAGE CELLAR

1 : 2 : 4 Mix

Cellar		Entranceway	
Footings	= 150 cu. ft.	Footing	= 4 cu. ft.
Inside walls	= 270 cu. ft.	Walls	= 6 cu. ft.
Outside walls	= 89 cu. ft.	Walls	= 18 cu. ft.
Parapet walls	= 8 cu. ft.	Walls	= 14 cu. ft.
Floor	= 76 cu. ft.	Floor	= 10 cu. ft.
Inside roof	= 109 cu. ft.	Steps	= 6 cu. ft.
Outside roof	= 77 cu. ft.	Steps	= 18 cu. ft.

Total 855 cu. ft.
= 31.67 cu. yds.

Material Required

Lehigh cement = 46 bbls.
Sand = 14 cu. yds.
Pebbles = 28 cu. yds.
Cinder fill = 62 cu. ft.

Reinforcement

Inside walls, ⅜" rods 12" on centers vertical and horizontal. Double rods around door. Diagonal rods, two 6' long at corners of doors. Reinforcement as illustrated for milk house on page 110.

ROOF

40 ½" round rods 12' 2" long = 486' 8"
20 ½" round rods 14' 8" long = 293' 4"

780 lin. ft.

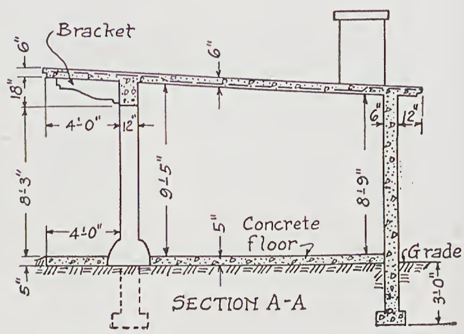
WALLS

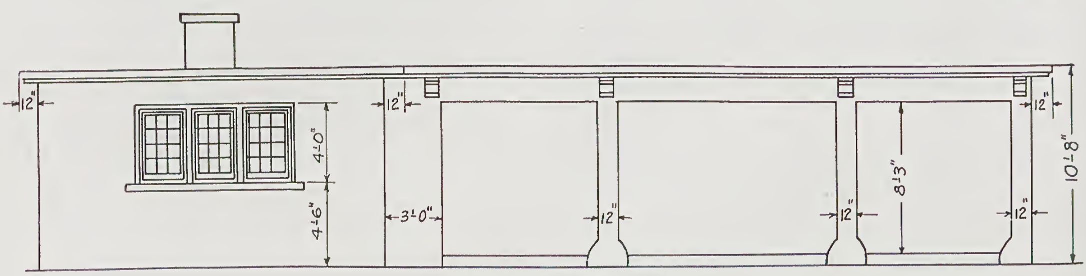
Vertical ⅜" round rods = 375'
Horizontal ⅜" round rods = 420'
Rods around door ⅜" round rods = 40'

835 lin. ft. of ⅜" rods

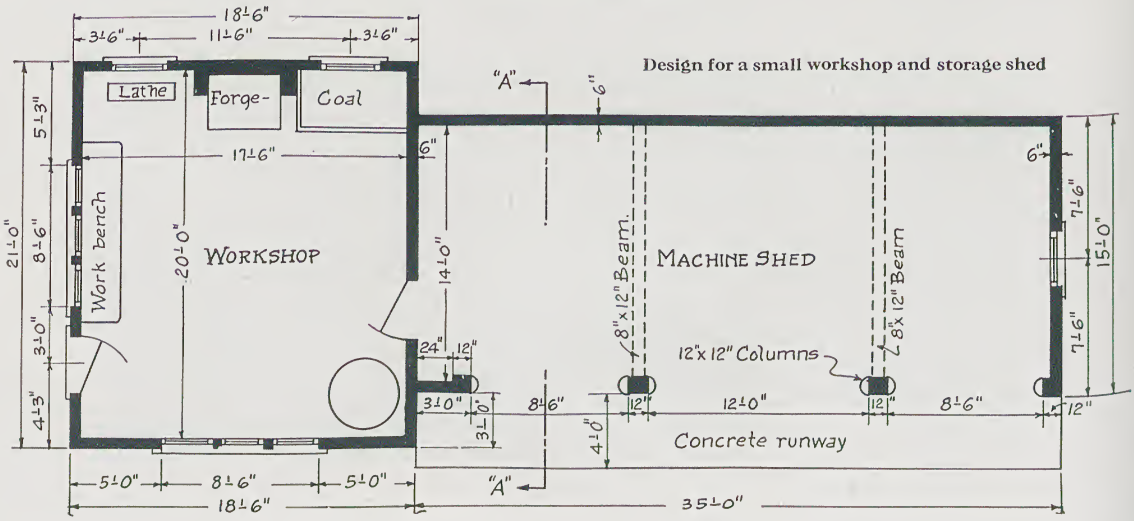
Farm Work Houses

SOME years ago several of the manufacturers of agricultural implements made a survey to show the depreciation of farm implements left exposed to the weather. The result of this survey disclosed a tremendous loss, which proved that proper care of farm implements, including their protection from the elements, was warranted. A farm workshop is also a paying proposition, because simple repairs to implements on the farm often save long and costly trips to town.

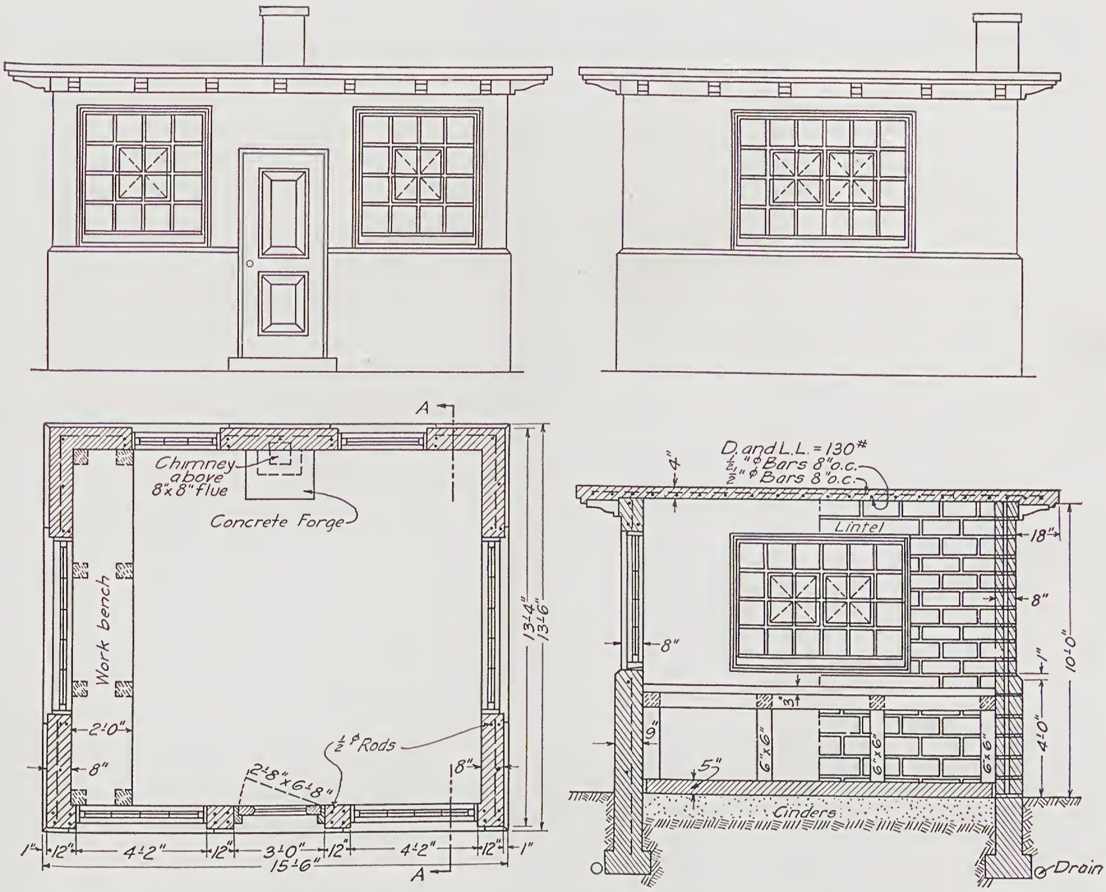




FRONT ELEVATION



Design for a small workshop and storage shed



Design for a workshop or a farm office, concrete block or monolithic construction

WORK HOUSE—MONOLITHIC

1 : 2 : 4 Mix

Walls	= 7 × .75 × 56	= 294 cu. ft.
Footings	= 6 × .67 × 56	= 225 cu. ft.
		519 cu. ft.
Deducting window and door openings		= 119 cu. ft.
		400 cu. ft.
Roof	= 16.5 × 18.5 × .33	= 100 cu. ft.
Floor	= 14 × 12 × .42	= 71 cu. ft.
		571 cu. ft. or 21 cu. yds. of concrete

Material Required

Lehigh cement = 32 bbls.
Sand = 10 cu. yds.
Pebbles = 20 cu. yds.

Steel Required

431 pounds
603 pounds
1,034 pounds of steel

Reinforcement

WALL REINFORCEMENT

Vertical rods ½" round	=	507 ft.
Horizontal " ½" "	=	168 ft.
For openings " ½" "	=	68 ft.
		743 ft. of ½" rods or 491 pounds

ROOF REINFORCEMENT

½" round rods = 900 feet or 603 pounds

WORK HOUSE—CONCRETE BLOCK

1 : 2 : 4 Mix

FOUNDATION

3 × .75 × 56 = 126 cu. ft.
15 courses of block @ 40 = 600 concrete block

LINTELS

2 lintels @	6′ 8″ × 8″ × 8″	= 6.0 cu. ft.
2 "	5′ 4″ × 8″ × 8″	= 5.0 cu. ft.
3 "	4′ 0″ × 8″ × 8″	= 5.5 cu. ft.
		16.5 cu. ft.

ROOF

96 cu. ft. of concrete

FLOOR

71 cu. ft. of concrete

Total amount of mon. concrete = 314 cu. ft. or 11.6 cu. yds.

Material Required

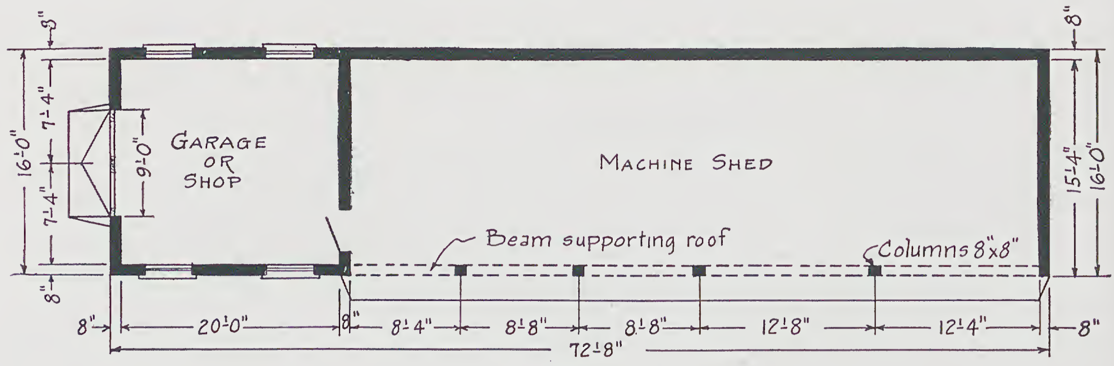
Lehigh cement = 18 bbls.
Sand = 5 cu. yds.
Pebbles = 10 cu. yds.

Steel for lintels

70 feet of ½″ round rods = 47 lbs.

Steel for roof

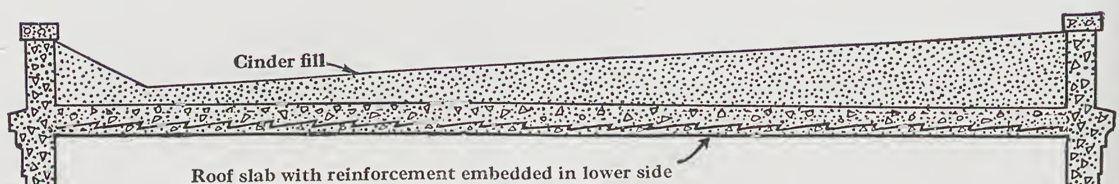
900 feet of ½″ round rods = 603 lbs.



PLAN

PERSPECTIVE

Since practically every farm has automobiles or tractors, this shed and workshop can be used as a protection against the weather



Concrete Roofs

UNLESS a building in which concrete is used for foundation and walls is finished with a concrete roof, a great measure of the fire protection of concrete will be lost. For many small buildings, such as garages, workshops, implement sheds, hog houses, and similar structures, flat concrete roofs can be used. Design of concrete roofs can be standardized somewhat for small buildings where span is narrow. Convenient reference tables follow, showing the quantity of reinforcing necessary for varying span and slab thicknesses.

THICKNESS OF ROOF SLABS IN INCHES

Width in Feet Between Center Lines of Walls	Length of Roof in Feet Between Center Lines of Walls						
	4 Feet	6 Feet	8 Feet	10 Feet	12 Feet	14 Feet	16 Feet
4 feet	2 in.	2 in.	2½ in.	2½ in.	2½ in.	2½ in.	2½ in.
6 feet	..	2½ in.	2½ in.	2½ in.	3 in.	3 in.	3 in.
8 feet	..	..	3 in.	3½ in.	3½ in.	3½ in.	4 in.
10 feet	..	..	..	3½ in.	4 in.	4½ in.	4½ in.
12 feet	..	..	..	..	4 in.	4½ in.	5 in.
14 feet	..	..	..	..	..	5 in.	5½ in.
16 feet	..	..	..	..	..	..	6 in.

Load = weight of roof + 50 pounds per square foot.

CEMENT, SAND, AND STONE OR PEBBLES

Required for Concrete Slab Roofs. Proportions for concrete 1:2:3. Each cubic yard of 1:2:3 concrete requires about 1.74 barrels of Lehigh cement, .52 cubic yard of sand, and .77 cubic yard of stone.
1 sack of cement considered as 1 cubic foot

Length of Roof in Feet Between Eaves		Width of Slab in Feet Between Eaves: 4 Ft.	6 Ft.	8 Ft.	10 Ft.	12 Ft.	14 Ft.	16 Ft.
4	Sacks of Lehigh Cement	0.7	..	..	..	..	..	..
6		1.0	2.0	..	..	..	..	..
8		1.7	2.6	4.2	..	..	..	..
10		2.2	3.3	6.1	7.6	..	..	..
12		2.6	4.7	7.3	10.4	12.5	..	..
14		3.0	5.5	8.5	13.7	16.4	21.2	..
16		3.5	6.2	10.1	14.4	20.8	26.7	33.3
4	Cubic Feet of Sand	1.4	..	..	..	..	..	..
6		2.1	3.9	..	..	..	..	..
8		3.4	5.2	8.3	..	..	..	..
10		4.3	6.5	12.1	15.2	..	..	..
12		5.2	9.4	14.6	20.8	25.0	..	..
14		6.1	10.9	17.0	27.3	32.8	42.5	..
16		6.9	12.5	20.2	28.8	41.6	53.4	66.6
4	Cubic Feet of Stone	2.1	..	..	..	..	..	..
6		3.1	5.9	..	..	..	..	..
8		5.1	7.8	12.5	..	..	..	..
10		6.5	9.8	18.2	22.7	..	..	..
12		7.8	14.0	21.8	31.2	37.4	..	..
14		9.1	16.4	25.5	41.0	49.1	63.7	..
16		10.4	18.7	30.3	43.2	62.4	80.1	99.8

Example.—How much material will it require to construct a roof 10 feet by 12 feet? Page 106 shows that a roof 10 feet by 12 feet requires a 4-inch concrete slab. The table above shows that for a 1 : 2 : 3 mix this roof will require 10.4 sacks of Lehigh cement, 20.8 cubic feet of sand, and 31.2 cubic feet of stone.

The table below shows that ⅜-inch round rods should be used for reinforcement. The rods running parallel to the 10-foot side of the building or across the span should be 7¾ inches center to center. The long reinforcement parallel to the 12-inch side should be spaced 16 inches center to center.

Where a roof is supported on girders, the close spacing refers to the rods extending across the girders, as that will be the short span of the roof slab, and the wide spacing refers to the rods parallel with the girders.

SPACING OF REINFORCING RODS IN INCHES

Width in Feet Between Center Lines of Walls	Length of Roof in Feet Between Center Lines of Walls: 4 Ft.	6 Ft.	8 Ft.	10 Ft.	12 Ft.	14 Ft.	16 Ft.	Size Steel
4 feet	12 in. 12 in.	9¼ in. 24 in.	8 in. 36 in.	8 in. 36 in.	8 in. 36 in.	8 in. 36 in.	8 in. 36 in.	¼ in. Round Rods
6 feet	.. ..	6 in. 6 in.	4¾ in. 12 in.	4 in. 36 in.	4 in. 36 in.	4 in. 36 in.	4 in. 36 in.	
8 feet	.. ..	.. ..	11 in. 11 in.	9½ in. 22 in.	9 in. 36 in.	7¾ in. 36 in.	7¼ in. 36 in.	⅜ in. Round Rods
10 feet	.. ..	.. ..	.. ..	8¾ in. 8¾ in.	7¾ in. 16 in.	7 in. 27 in.	6½ in. 36 in.	
12 feet	.. ..	.. ..	.. ..	.. ..	6½ in. 6½ in.	5¾ in. 12 in.	5¼ in. 16 in.	
14 feet					.. ..	5¼ in. 5¼ in.	4½ in. 8¾ in.	
16 feet	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	4 in. 4 in.	

Note.—Upper figures are for cross reinforcement; lower figures for long reinforcement.

Load = weight of roof + 50 pounds per square foot

The separators should be placed convenient to the cooling tanks

Dairy and Ice Houses

THE size of a dairy house is largely dependent upon the size of the herd, whether whole milk or only cream is to be cared for, and whether or not necessary refrigeration can be applied while the milk is being held preparatory to shipping. Size of the milk house should always be limited to those dimensions which will provide for handling milk only. Otherwise surplus space will soon become storage room for many undesirable articles that have no place in a building where milk is handled. Such twofold use contributes to insanitary conditions and defeats the purpose for which concrete was primarily used. More than one creamery company compels its patrons to build certain types of concrete milk houses if they expect the creamery to buy their product.

The dairy house should be easy of access from the farm house, the barn, and the ice house. Incidentally, no farm where ice can be harvested easily should be without this last structure.

The site for the milk house should be one insuring good soil drainage, and some natural shade is an advantage in summer, although the sterilizing effect of sunlight should not be overlooked.

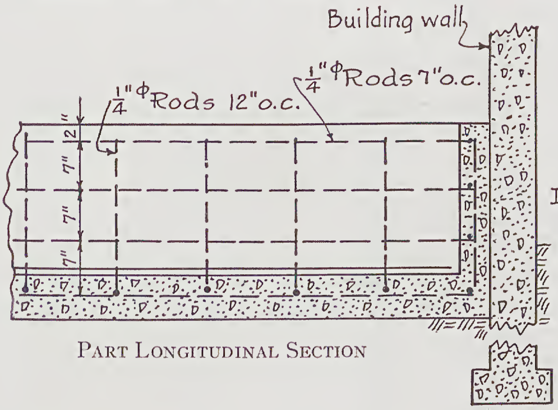
Good circulation of air is necessary, and should not be left entirely to chance or occasional opening of doors and windows. A metal ventilator built in the roof, with suitable inlets, will provide for thorough circulation.

During the warm months the windows will usually be left open, so they should be screened with non-rusting screen cloth to keep out flies and other insects. An almost indispensable adjunct to the milk house is a cooling tank, which is built essentially the same as a stock watering trough. Inlet and overflow fittings should be provided, with proper consideration for the depth of water to be maintained in the tank so that cans will be kept submerged well up around their necks. Grooves cast in the bottom of the tank while its floor is being concreted will provide for adequate circulation of water under the cans. This groove can be formed by pressing several triangular strips of wood into the concrete before it has hardened and afterward removing them.

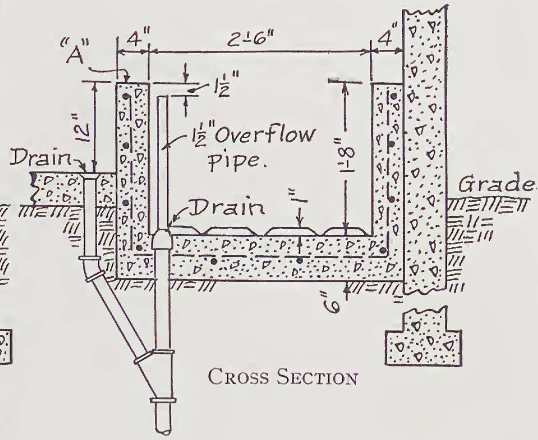
Frequently an ice house and milk room are combined. With a home supply of ice available, the contents of the tank can be kept cool by keeping chunks of ice in it. Otherwise spring water may be circulated through the tank.

Often a spring is enclosed with a concrete building which becomes the milk house after the spring has been properly walled with concrete.

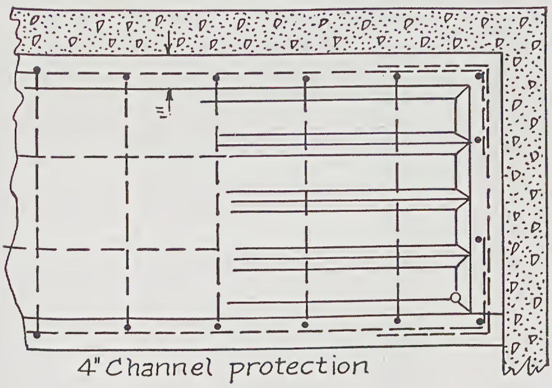
It has been estimated that at least 30 per cent of such dairy products as milk and cream is wasted on the farm, due to lack of or



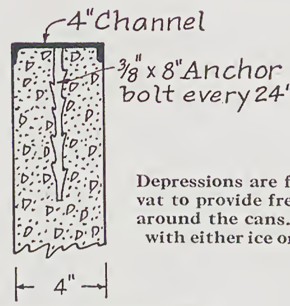
Part Longitudinal Section



Cross Section



Part Plan



Enlarged Detail at "A"

Depressions are formed in this cooling vat to provide free circulation of water around the cans. Keep the water cool with either ice or flowing spring water

MILK COOLING VAT

Assume 6′ 0″ long. 1 : 2 : 3 Mix

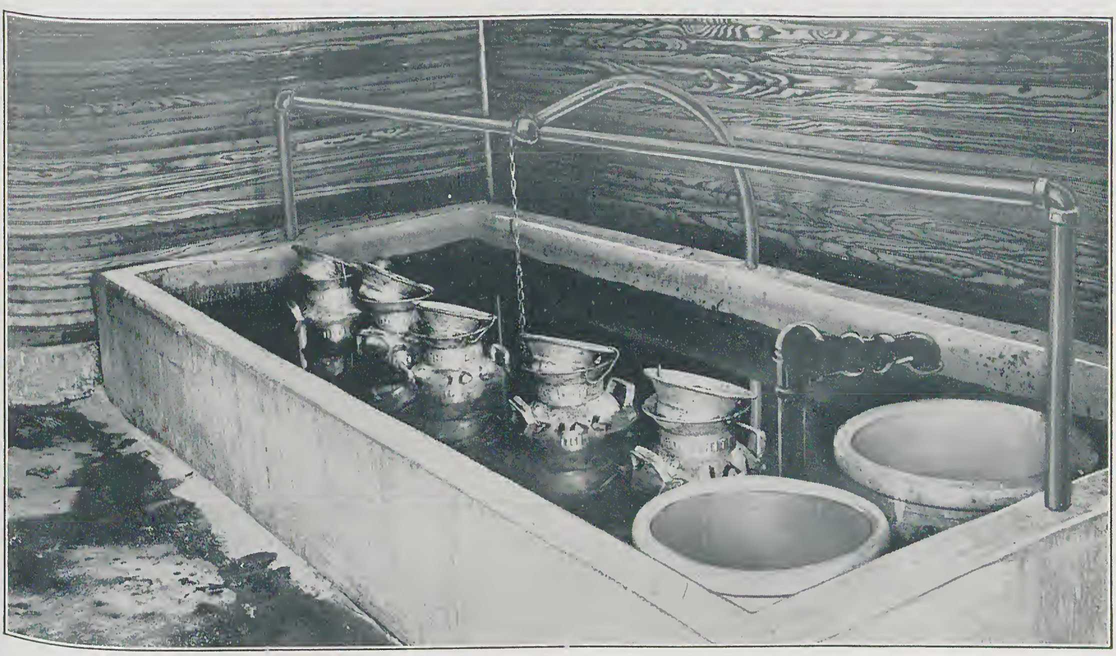
Walls	= 6.6 cu. ft.
End walls	= 2.8 cu. ft.
Bottom	= 9.5 cu. ft.
	18.9 cu. ft. or .70 cu. yd.

Material Required

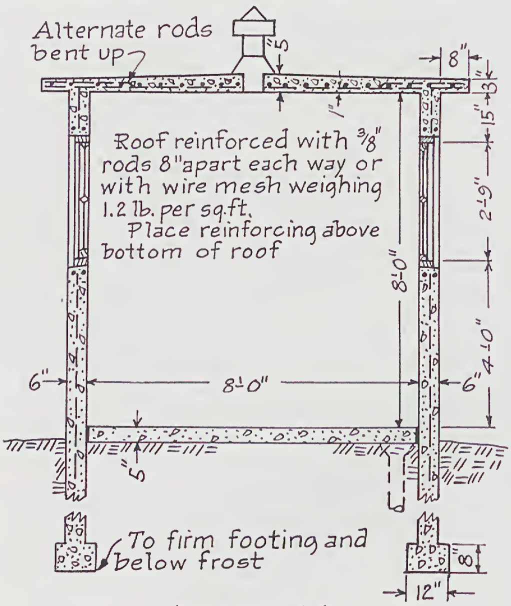
Lehigh cement	= 1.2 bbls.
Sand	= .36 cu. yd.
Pebbles	= .54 cu. yd.

Reinforcement

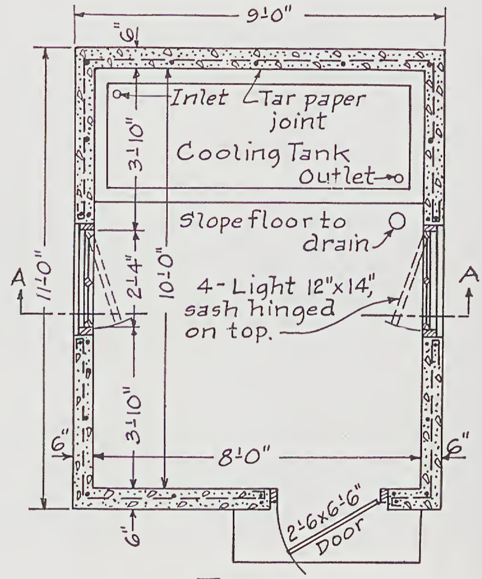
143 lin. feet of ¼″ round rods or 24.5 lbs.



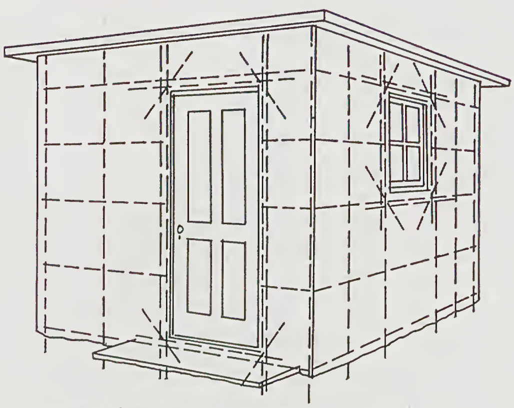
The depth of this cooling vat insures cans being well submerged



SECTION A-A



PLAN



Wall reinforced with 3/8" round rods as shown. Rods doubled around openings and continous around corners. Diagonal rods 2'-6" long at corners of openings.

MILK HOUSE

1 : 2 : 4 Mix

Walls	= 209.0 cu. ft.
Floors	= 33.6 cu. ft.
Footings	= 27.0 cu. ft.
Roof	= 54.0 cu. ft.
	323.6 cu. ft. or 12 cu. yds.

Material Required

Lehigh cement	= 18.12 bbls.
Sand	= 5.4 cu. yds.
Pebbles	= 10.8 cu. yds.

Reinforcement

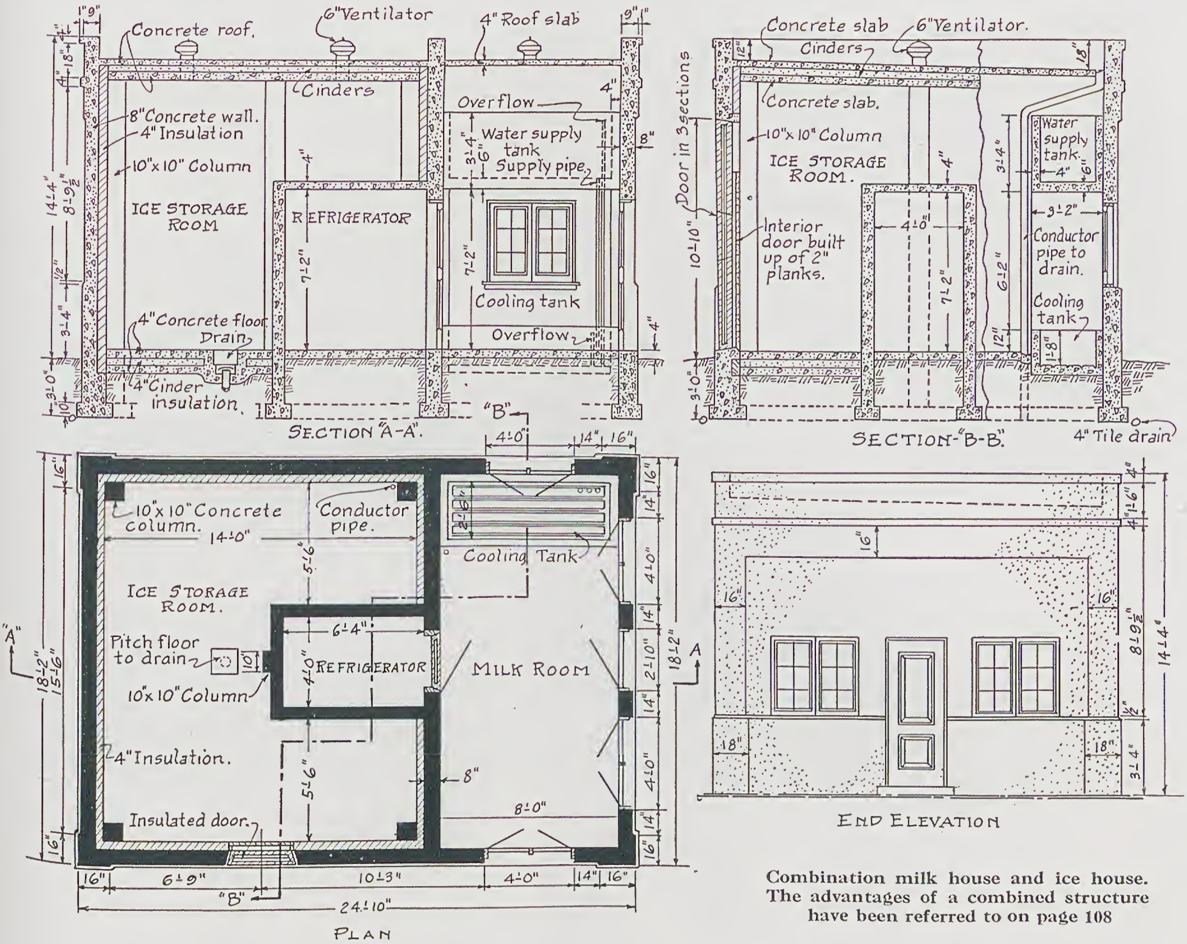
Roof (3/8" round rods)	398 ft. or 144 lbs. of mesh
Walls (3/8" round rods)	450 ft.
	848 lin. ft. or 322 lbs.

This design for a small milk house with cooling tank is of monolithic construction, showing method of reinforcing the walls

insufficient cooling facilities. The products spoil before they can be marketed. These figures are based on careful studies of the United States Department of Agriculture and enable any one to prove to himself that the cost of a milk house is soon returned through prevention of waste.

Concrete Ice Houses

From the nature of the stored contents ice houses are subjected to varying degrees of dampness. Rot-proof qualities of concrete provide construction that is not affected by these conditions. Wooden ice houses after two or three years require such continual repair that within five years the expenditures to keep them in usable condition will amount practically to rebuilding. All of this is done away with through permanent concrete construction. Practical dimensions for a small ice house are 10 by 10 by 10 feet. This provides a gross capacity of 1,000 cubic feet. Ice weighs approximately 57 pounds per cubic foot, and allowing for packing material, storage capacity in an ice house of the dimensions given would be at the rate of 40 pounds per cubic foot, or, in other words, 20 tons. These figures will enable any one to estimate for greater capacity if required. Concrete block are particularly suited to concrete ice house construction because of the air

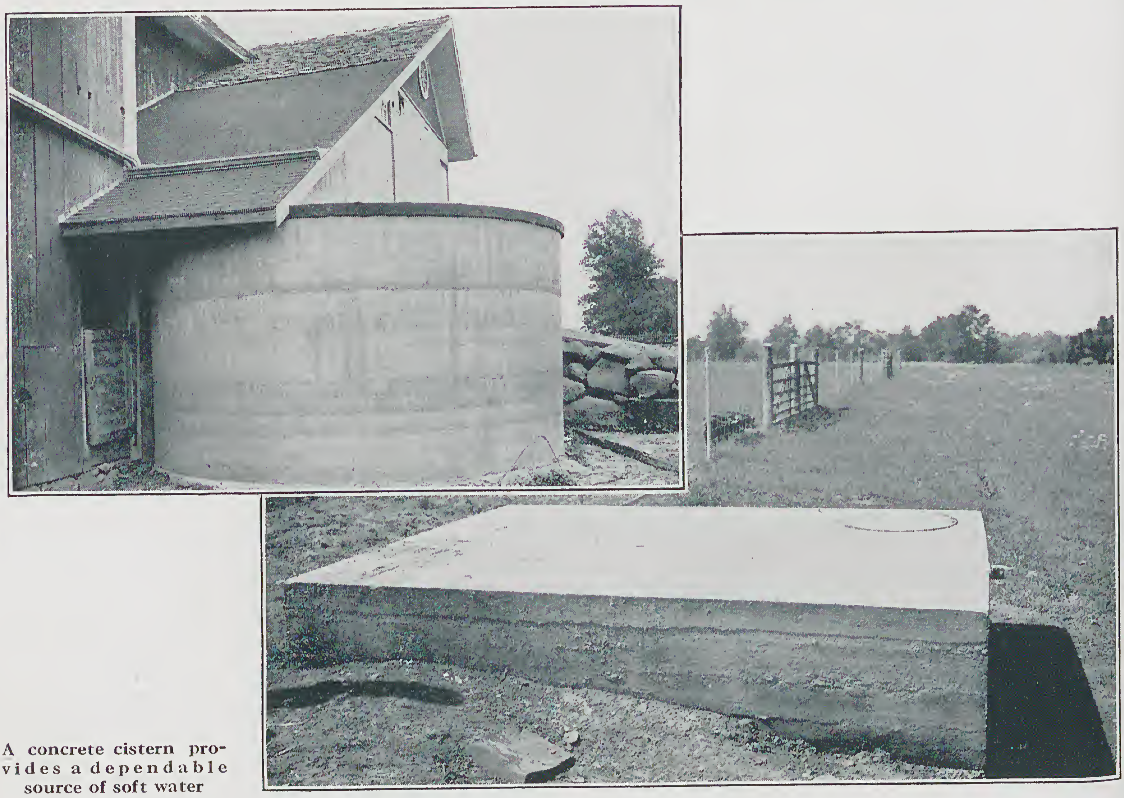


Combination milk house and ice house. The advantages of a combined structure have been referred to on page 108

Section	Yardage	Mixture	Bbls. of Lehigh cement	Cu. yds. sand	Cu. yds. 1 in. stone
Footings	= 185 cu. ft. = 6.85 cu. yds. of concrete,	1 : 3 : 6 mix, requiring	6.92	3.15	6.30
Foundations, Walls, Floors	= 1668 cu. ft. = 61.78 cu. yds. of concrete,	1 : 2 ½ : 4 mix, requiring	83.40	32.13	50.66
Columns, Roofs, Tanks	= 351 cu. ft. = 13.00 cu. yds. of concrete,	1 : 2 : 3 mix, requiring	22.10	6.76	10.01
	Approximate total required		113	42	67

5½ cu. yds. cinder fill

spaces introduced in the walls which provide sufficient insulation to reduce meltage of ice to a minimum, regardless of outside temperature conditions. The concrete floor in an ice house should have a drain to carry away meltage, but this drain should be trapped so that it will be sealed against possible entrance of warm air. When monolithic concrete is used for an ice house, sometimes double wall construction is used to provide insulation in the wall, or a veneer of hollow tile is laid on the inside for the same purpose. The concrete roof is insulated by laying two separate slabs separated from each other by a layer of clean cinders. Ice house walls, both monolithic and block, must be reinforced in a manner similar to the reinforcing of silos to provide against bursting due to pressure of contents which may shift so as to throw considerable weight against the walls.

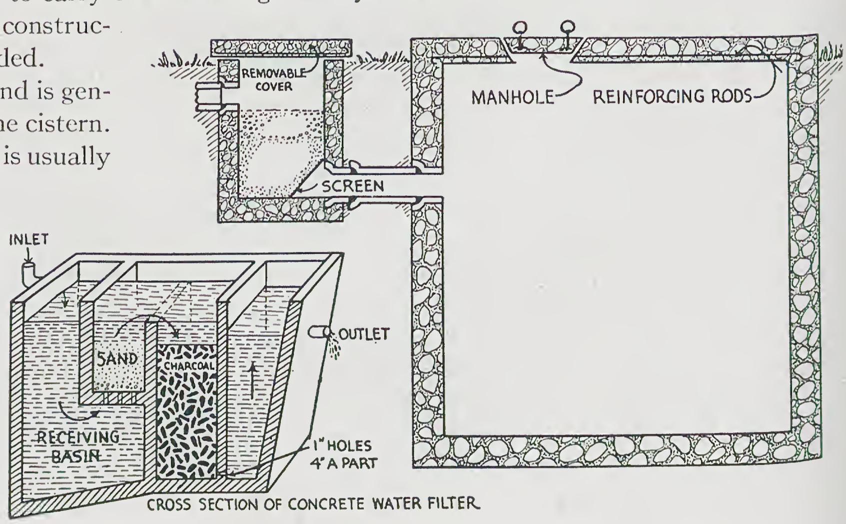


A concrete cistern provides a dependable source of soft water

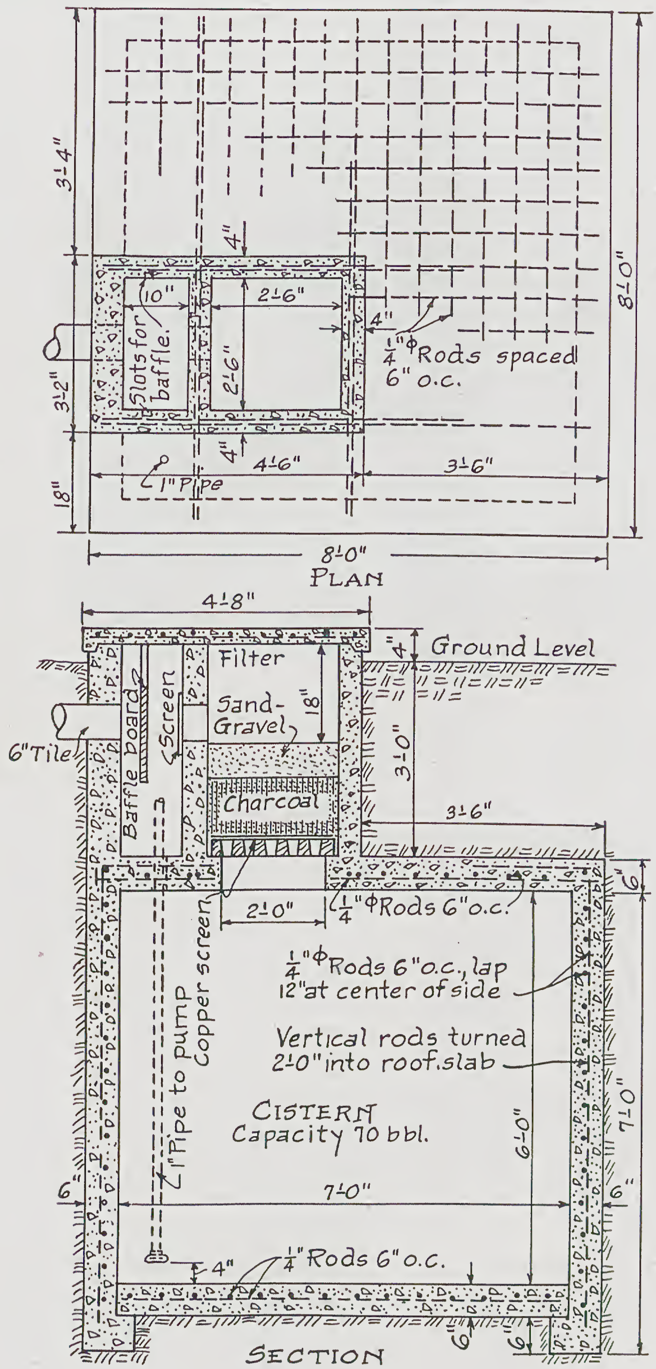
Cisterns

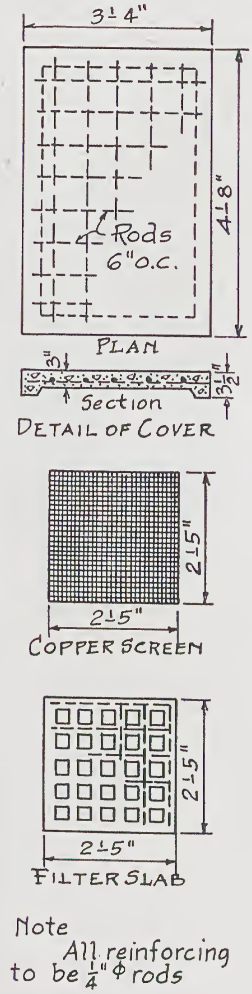
A CISTERN is nothing more nor less than a tank, and the fundamental requirements of tank construction have been described on pages 93 to 96. Cisterns have been built of brick and stone masonry, but this class of construction cannot be depended upon for watertightness, even when plastered. Concrete is, therefore, the ideal cistern construction material. As in other forms of tanks, it is well to arrange, if possible, to carry on concreting continuously, so that construction seams will be avoided.

A filter is desirable and is generally made a part of the cistern. The filter compartment is usually built so that it will contain a layer of granulated charcoal, on top of which a layer of clean, well-graded sand and gravel is placed. A screen of ¼-inch copper wire is placed over the pipe opening into the cistern to prevent leaves and other refuse from clogging up the filter-bed. Every cistern is the subject of special design. The accompanying sketches of cisterns which have been built are complete in every detail of construction.



Section of a typical underground concrete cistern. Two types of filters are shown





This design for a concrete cistern provides for 65 bbl. capacity. Reinforcement details are complete. A filter in a cistern is necessary

CISTERN

1 : 2 : 4 Mix

Bottom	24.50 cu. ft.
Top	24.50 cu. ft.
Cover	3.89 cu. ft.
Footing	12.00 cu. ft.
Main walls	112.00 cu. ft.
Monitor walls	4.75 cu. ft.
Monitor walls	15.00 cu. ft.
Total	196.64 cu. ft. = 7.283 cu. yds.

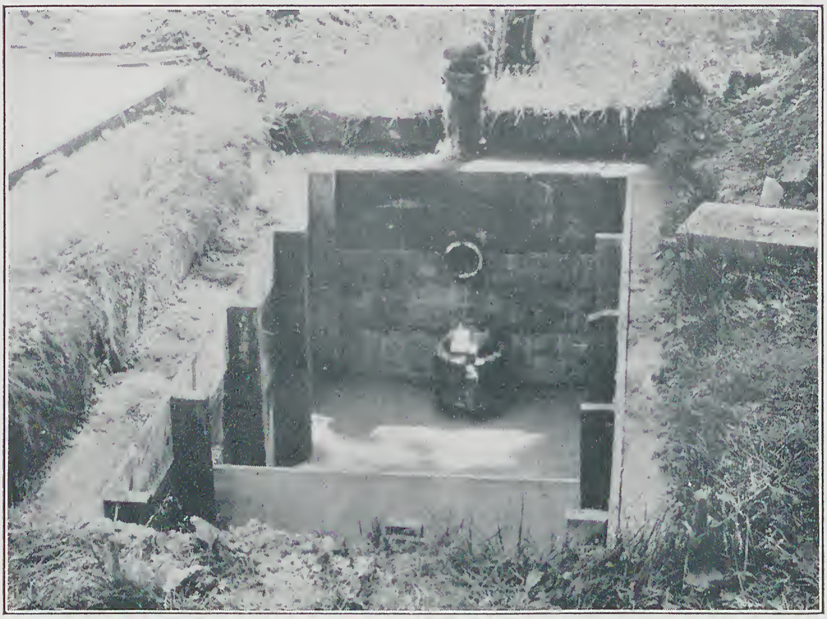
Material Required

Lehigh cement	=	11 bbls.
Sand	=	3 cu. yds.
Pebbles	=	6 cu. yds.

Reinforcement all 1/4″ Rods

Top and bottom	60 rods	7′ 6″ long	= 450′ 0″
Cover	5 rods	4′ 3″ long	= 21′ 3″
Cover	8 rods	3′ 0″ long	= 24′ 0″
Main walls	15 rods	34′ 0″ long	= 510′ 0″
Main walls	60 rods	9′ 0″ long	= 540′ 0″
			1545 lin. ft.

Tie wire to be included.



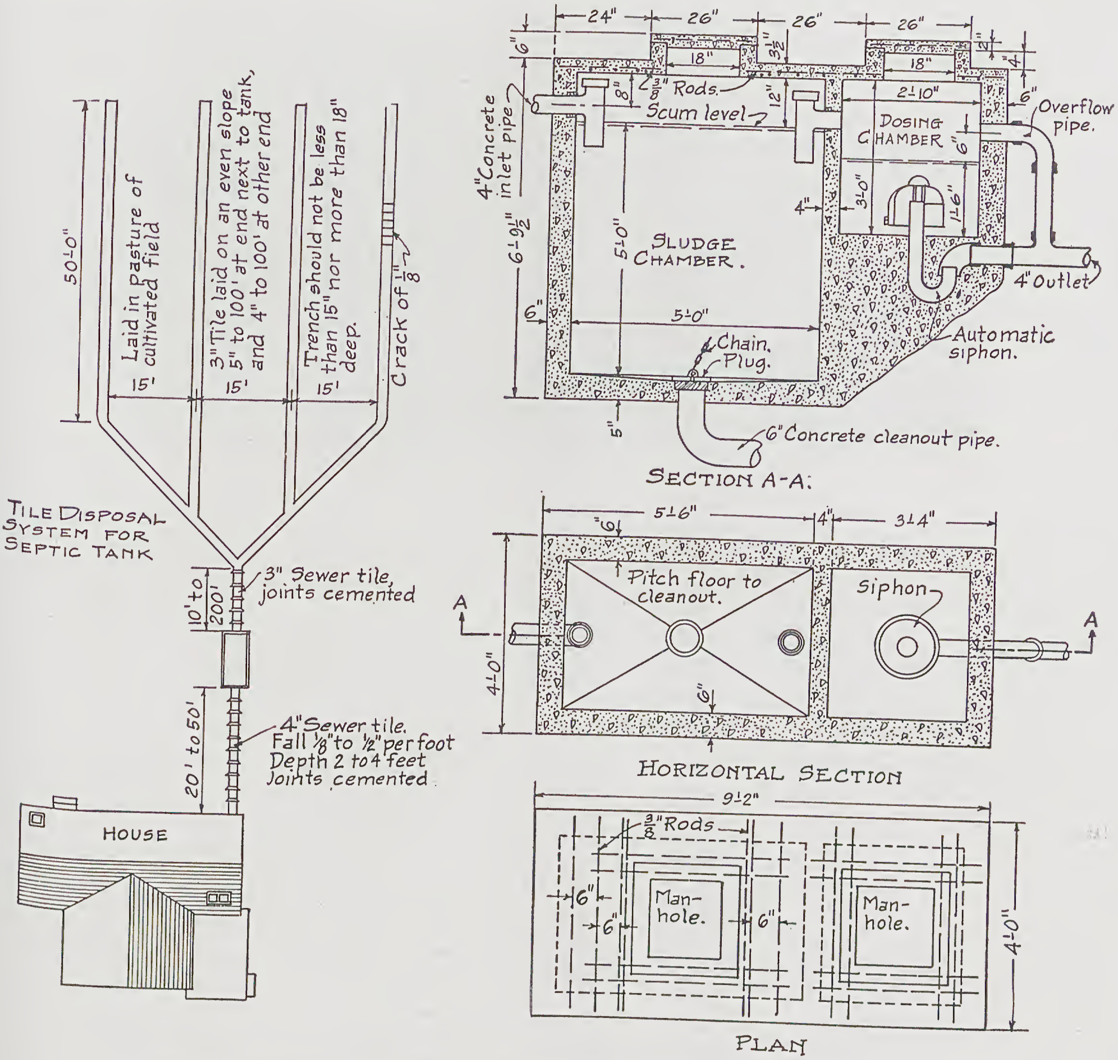
A concrete septic tank, showing siphon in place, ready to remove forms and cast the cover

Septic Tanks

THE principle on which the septic tank works is one of bacterial action. If ordinary household waste is confined in a practically air-tight and dark compartment, such as the first chamber of a septic tank provides, the solids commence to break up, due to the development and action of bacteria. These feed on the solids and semisolids in the wastes and convert them into gas and relatively harmless compounds. After certain transformation in the first compartment, some of the contents are discharged into a second compartment, where further transformation takes place and the sewage is rendered even less harmful and less offensive. Finally the second compartment discharges into a tight tile line which should have laterals laid with open joints through which seepage of liquids into the soil can take place where final and complete destruction of harmful elements is performed by the action of other bacteria native to the soil.

Practically all successful septic tanks embody the essential features shown in a sketch on page 115. They may appear somewhat different, but fundamentally they are the same. Sewage from the house mains enters the first compartment, then overflows to the second, and finally is discharged from that compartment at regularly timed intervals by an automatic, mechanically controlled device installed in the second compartment, known as a siphon. These siphons can be set to discharge the contents of the second compartment at predetermined intervals. This is necessary in order that time control be exercised with respect to holding the sewage undisturbed for a given length of time to permit completion of a certain stage of bacterial action.

Septic tanks are made in various shapes, and if they embody the underlying principles, shape is unimportant. One type is precast in units somewhat similar to lengths of large sewer or culvert pipe with fittings that permit assembling where they are to be used in series of two, three, or more tanks, the idea of the series being to provide for additional capacity. For the person intending to build a septic tank a rectangular shape is the best because of the ease with which concrete forms can be built. The depth of such a tank should be not less than four feet below the opening of the pipe which discharges wastes into the tank. The total depth of the fluids in the first tank should be not less than five feet. If practical, a greater depth is desirable. As mentioned, discharges from the second compartment, or siphon chamber, should be carried by a line



A miniature home sewage disposal plant which, within natural limitations, disposes of household wastes in a manner to render them practically harmless. The principles of construction are as outlined under discussion of "Tanks." One of the sketches makes clear the manner of connecting the tank to the house and in turn to the tile lines leading to the disposal field

SEPTIC TANK—1 : 2 : 4 Mix

Solid base under siphon	46.66 cu. ft.
Less corner not filled	15.83 cu. ft.
	30.83 cu. ft.
Outside wall	48.75 cu. ft.
Outside wall	16.50 cu. ft.
Inside wall	4.00 cu. ft.
Bottom	4.00 cu. ft.
Top	10.79 cu. ft.
Curbs around manhole	1.67 cu. ft.
Two covers	2.95 cu. ft.
	119.49 cu. ft. = 4.426 cu. yds.

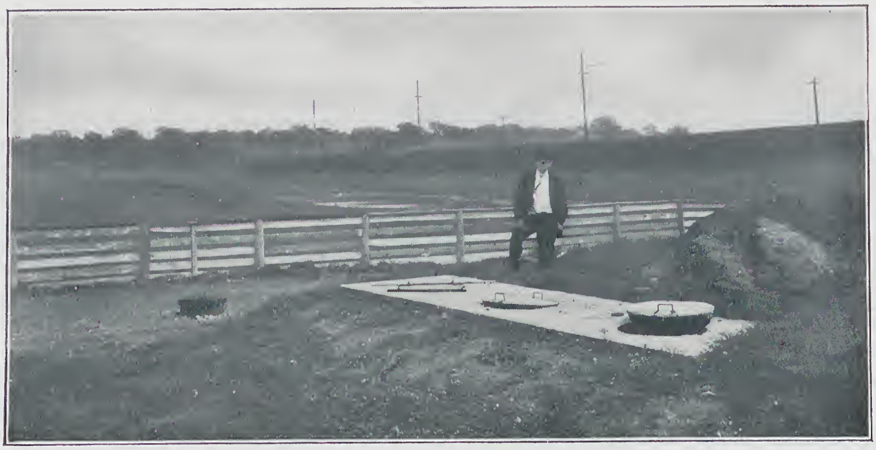
Material Required

Lehigh cement	= 7 bbls.
Sand	= 2 cu. yds.
Pebbles	= 4 cu. yds.

Reinforcement

For top: 15 3/8 in. rods, 3 ft. 6 in. long
4 3/8 in. rods, 4 ft. long

of tile made of dense, non-porous drain tile laid with cemented joints up to the point where final disposition is to be made of the wastes. This area is generally called the disposal field. The lateral lines receiving discharges from the main tile line should be laid with open joints. Sometimes disposal is accomplished by what is known as surface irrigation. This means allowing the liquids discharged from the siphon department to flow over the land, where combined action of sun and soil bacteria renders them harmless.



Cover for septic tank, showing removable cover

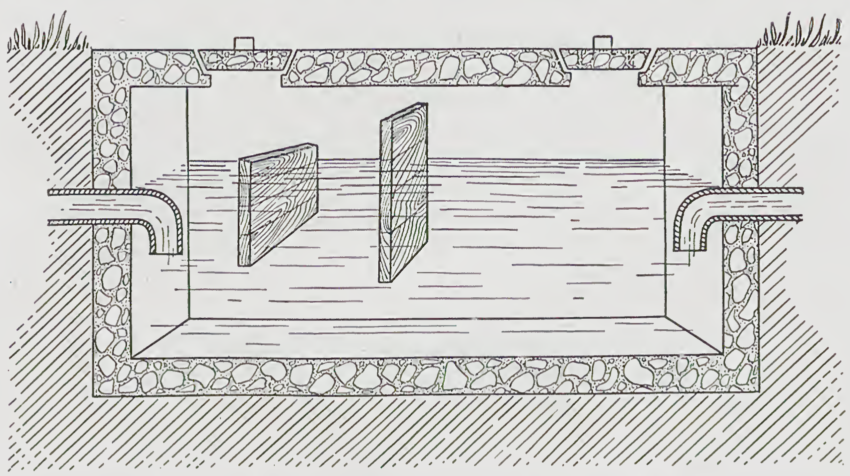
Frequent light cultivation of this area without cropping keeps it in better condition to receive and dispose of tank discharges. Once put into operation, the septic tank is self-operating, because of the automatic siphon.

Experience seems to prove the desirability of building a septic tank of capacity sufficient to contain twenty-four hours' flow of sewage from the household which it serves. Required capacity can be approximately determined by estimating that the discharges into the tank will range between 30 and 50 gallons per person per day. The length of the tank should be about twice its width, so that uniform velocity of flow through it may be obtained.

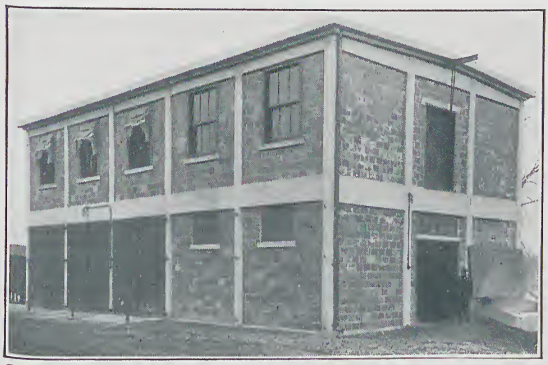
It is necessary that the method provided for the entrance of household wastes into the tank be such as to break up the inrush or rapid flow action and prevent the disturbance of the scum which forms in this compartment. Baffle boards or special Y-pipe fittings are used, the latter method consisting of having one end of the Y submerged below the constant level of fluids in this compartment. The scum must not be broken, disturbed unnecessarily, nor allowed to leave the first compartment, as it is the home of the bacteria which do the work of sewage reduction. The principles of constructing a concrete septic tank, so far as the concrete work goes, are the same as those applying to any form of tank, such as a cistern, etc. See pages 93 to 96.

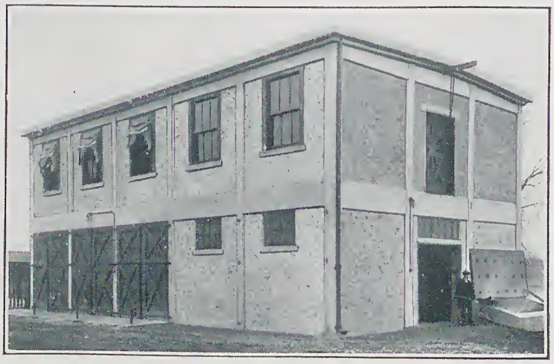
Sewage must enter from the house at one end of the tank and leave at the other end. A grease trap must be placed in the line from house to tank. The flow through the tank should be slow and as uniform as possible.

As a rule, subsurface disposal is best for the single residence if soil conditions are suitable. This system usually requires less attention and the discharges from the tank are entirely out of sight at all times.



Cross-section of septic tank with baffle boards in place. Inlet and outlet pipes are cast in position





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Portland cement stucco has many advantages

Portland Cement Stucco

PORTLAND cement stucco is a cement plaster used to finish the exterior walls of frame, brick, tile, or concrete structures, and to renovate outside surfaces of old buildings.

The merits of stucco are its ease of application, the fire protection it affords, and the elimination of maintenance.

Stucco is done without forms, and if guided by proper specifications, results are attractive and lasting. In the case of a frame structure the strength of the building and its durability are increased.

Stucco should not be confused with the ordinary plastering done with lime sand mortar. In the modern acceptance, stucco means a mortar prepared of Portland cement and sand, in which a small quantity of hydrated lime may be present to increase the mixture's plasticity. The stucco building may consist of a timber or metal frame covered with cement plaster, preferably with metal lath used as the "ground." Stucco is also applied to masonry construction.

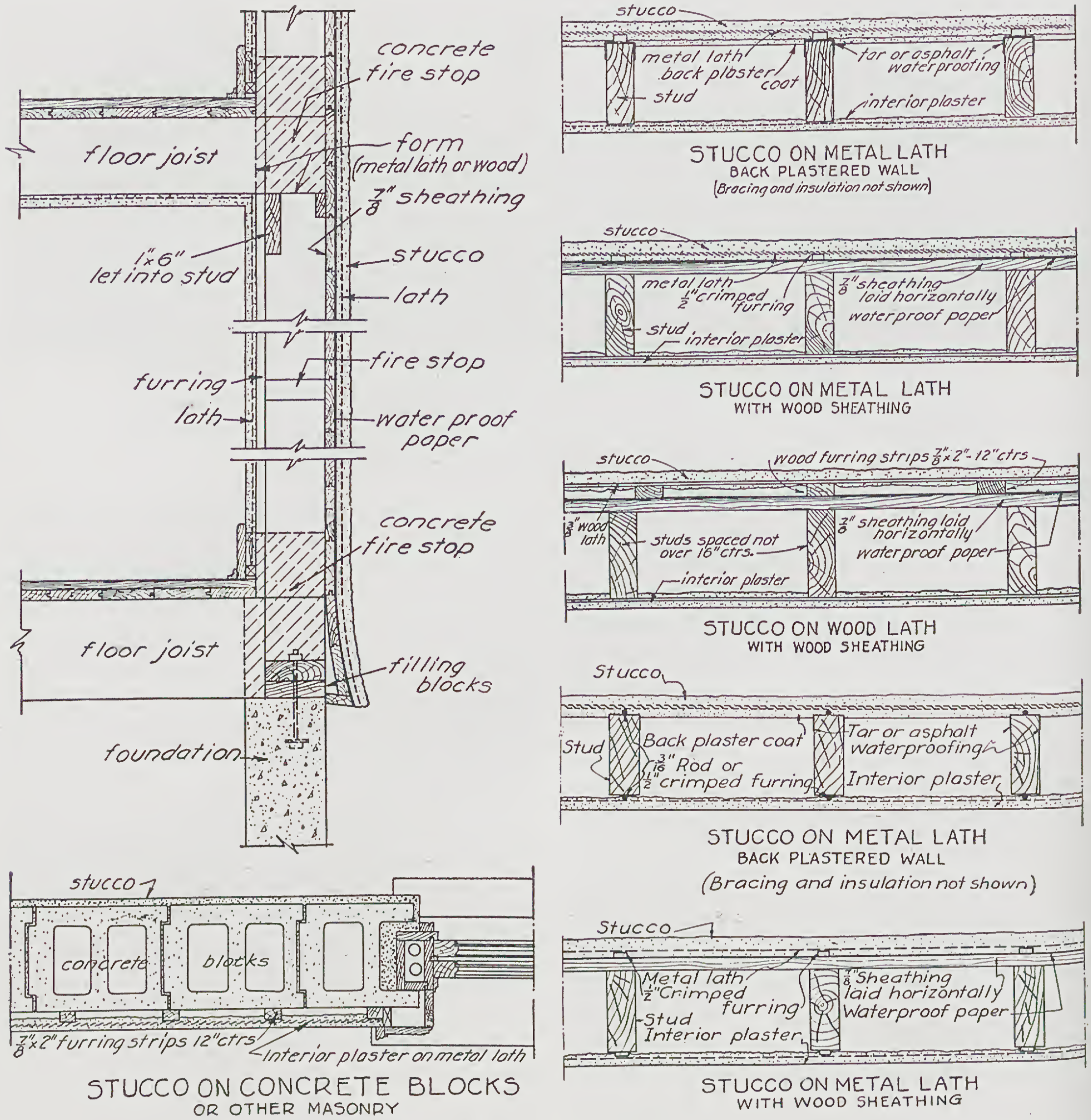
For best results on frame buildings stucco should be applied to metal lath or woven mesh fabric which has been previously fastened to the building studs or sheathing. Wood lath nailed directly to wood studs or furring strips nailed over the sheathing or over the old siding in remodeling an old structure are also used. In all cases it is better to remove the siding before furring and lathing the surface to be stuccoed.

The framing of studding should be done so that the structure will form a rigid support for lath and plaster; otherwise, if there should be settlement of the structure, the stucco will crack. Frame buildings, to be dry, should be covered with sheathing boards over which waterproof building paper has been laid before furring and lathing. In covering old frame buildings the furring strips may be nailed directly on the weatherboards when the surface is rigid and true. The best practice is to remove weatherboards and apply furring or lath to the studs or sheathing. Wood furring strips should be not less than ½ inch thick and about one inch wide.

Sometimes ¼-inch round rods are used with metal lath rods acting as furring strips to hold the metal lath from the sheathing to provide space necessary for the stucco plaster to key or clinch. The metal lath is wired to the rods, which are first attached to the sheathing by staples.

Metal lath is made both with and without stiffening webs. These stiffeners are in the nature of ribs formed in the material at the time it is shaped in manufacturing. Metal furring should be used with metal lath because wood strips are bulky, interfering with the clinch or bond of the plaster and preventing a thorough coating of the lath at that point. Furring strips on studding should be placed not more than 16 inches apart, to give proper stiffness to the lath. Each furring strip, whether of wood or metal, should be securely attached to the studding, sheathing, or weatherboarding at intervals not greater than one foot. One kind of metal lath made from slotted metal is expended into diamond-shaped mesh of different sizes, and can be obtained in various weights or thicknesses.

Wire lath is made from wire of different sizes woven to form a network of fabric having meshes about ⅓ inch square. Such lath comes both japanned and galvanized.



Details of stucco construction

The galvanized type is preferable if it has been galvanized after the fabric was woven, as the coating assists to tie or bond the wires of the fabric where they cross or intersect. Sixteen-inch spacing of furring accommodates 36-inch wire lath, allowing it to lap two inches on the sides.

Metal lath should be lapped at least one inch wherever joined, and should be fastened securely to the furring strips or studding so as to prevent sagging or bulging.

Most of the unsatisfactory examples of stucco work are due to disregarding important fundamentals when wood lath are used as a ground. Only the best quality of wood lath should be used and they should be well wet down before applying the plaster. If this is not done, the lath will absorb moisture from the stucco, preventing the cement in the mixture from properly hardening. If the lath are too wet, they will shrink later and separate from the plaster in places, thus weakening the key. In either extreme cracking is likely to follow and the plaster may finally loosen and fall off. With metal lath all danger of shrinkage is avoided, and the additional cost is not enough to justify the use of wood lath. When wood lath is used, it should be placed so that spaces between are about ¼ inch wide. Secure nailing at each point of intersection with a stud or furring strip is necessary. Most important of all, wood lath


Stucco can be applied to either a brick or a tile base

should be covered with a strip of wire netting or mesh fabric at corners and recesses, to prevent cracks in the wall at these points. Simple and inexpensive as this precaution is, it is more often neglected than observed.

Stucco is used to a considerable extent to renovate old brick structures and to give a more attractive surface finish to ordinary concrete walls. There is no better ground for the application of stucco than rough cast concrete block. In making concrete block for stucco finish, no care is taken to produce an even surface texture. The intention is to allow the surface to present small aggregate pockets in order that the stucco may more firmly bond to it.

In applying Portland cement stucco to walls of concrete or masonry, the surface to be stuccoed must be roughened enough to secure proper bond for the stucco and must be thoroughly cleaned by brushing and washing in order to remove loose particles, dust, soot, or any other material that would reduce adhesion between stucco and the surface to be covered. In such masonry as brick, the mortar joints should be picked out to a depth of at least ½ inch from the face of the wall, so as to increase the bond between the stucco and the wall surface. In the case of new brick walls the joints at the face of the wall are purposely left unfilled to provide this key. Chimneys should be furred and lathed before they are stuccoed, otherwise the changing conditions in their walls as regards heat inside and cold outside may cause the stucco to crack and fall off. All walls should be thoroughly drenched with water immediately before the stucco is applied.

Stucco is usually applied in three coats, designated as the first coat, intermediate coat, and the finish coat. When plastering on masonry, however, the intermediate coat is sometimes omitted and the finish coat applied directly to the first coat. For best results no plaster coat should be more than ½ inch thick. When the framework of the walls is composed of wood studding, lath and plaster are usually applied to both sides of the studding, forming a double wall, but for small buildings and sheds the plaster covering on metal lath applied to the studding outside is often all that is required. This is particularly true of such structures as the average farm outbuildings. In such cases the lath should be given a coat of plaster on the inner surface as soon as the first exterior coat has hardened sufficiently. This will thoroughly cover the metal and protect it against rust from dampness. In addition it will add strength by stiffening the frame.

Among the tables published on page 181 will be found one for estimating the amount of cement and sand required to cover walls with stucco of different thickness and proportions of mixture. This table does not take into consideration waste of mortar. Waste,

Stucco with architectural trimstone medallion over doorway

A before and after illustration. Stucco was applied to metal lath

however, can be lessened by placing a plank on the ground at the base of the wall while plastering to catch mortar as it falls. None of this waste should be used after it has commenced to harden. In fact, every batch of stucco mortar should be completely used up before it is thirty minutes old.

For the first coat a mixture of 1 part cement to 1½ parts clean, coarse, well-graded sand is generally used. Sometimes hydrated lime is used in the first coat, as well as in subsequent ones. The second and following coats should be applied only after the first coat has thoroughly hardened, but preferably before it has had time to dry out completely. The first and second coats should be scratched with some kind of a saw-toothed tool, so as to roughen the surface and provide for a better bond of subsequent coats.

Several surface finishes may be given to stucco—smooth, brushed, rough-cast, and pebble-dash. The smooth finish is obtained by bringing the final coat to a true and even plane with a wooden float or trowel. A wooden float is preferable because the steel trowel is likely to be overused and bring to the surface a film of neat cement which hair cracks.

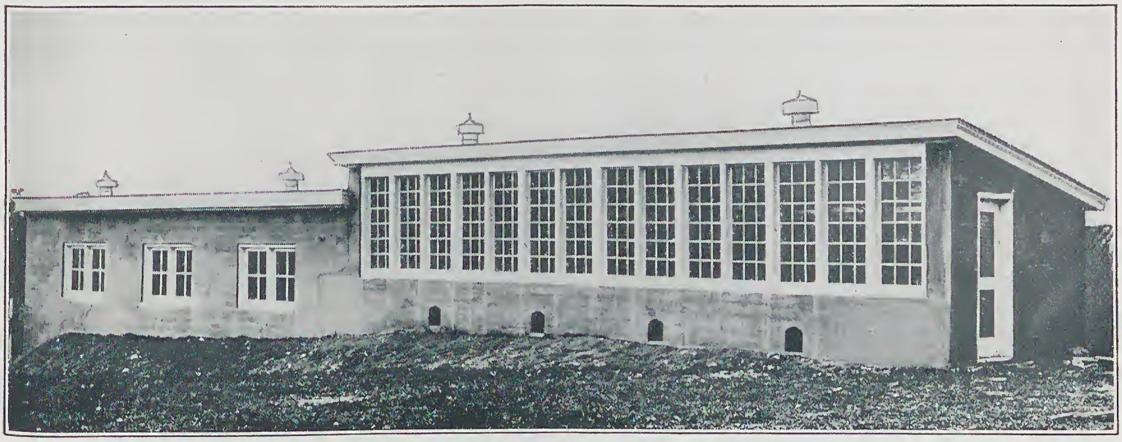
The brushed surface is secured by using a wire brush or broom after the surface has partly hardened, giving a uniformly pleasing effect.

The rough-cast finish is obtained by throwing against the wall from the hand or from a paddle or swab of tightly bound pliable twigs the prepared mixture for the finish coat. Sometimes a portion of the sand is replaced by an equal amount of small, even-sized pebbles, producing the pebble-dash, the pebbles being thoroughly wet and mixed in a thin cement and water grout, then thrown against the plaster coat while soft with sufficient force to make them partly embed in the surface. Some practice is required to produce a uniform surface finish by slap-dash or pebble-dash treatment. The texture of this finish varies in accordance with the size of the pebbles used in the mixture. It is very important that dust and all foreign material be removed from the pebbles and sand before they are used in the mixture.

In doing stucco work it is well to lay out a definite area to be done during one day's operations, so that the entire section can be completed within the specified time. This will produce uniformity of texture and color and will prevent the appearance of irregular line markings on the finished surface, indicating where the work was interrupted for a time. Measure materials so as not to have variations in color owing to differing proportions.

It is also very essential to protect the plaster from freezing temperatures by covering with canvas or burlap hung up against the walls; also to protect newly placed stucco against too rapid drying out from sun or wind. In the latter case the protective covering should be kept wet, and after the plaster surface has hardened sufficiently to permit spraying with water, the wall should be kept sprinkled for several days. This practice is insisted upon by the most approved specifications for stucco, yet any one who has observed stuccoing in process has probably noted that the precaution is almost invariably omitted.

Sometimes coloring-matter is used in the finish coat. Only permanent mineral pigments should be used, and the variety of colors possible is somewhat limited, owing to the fact that many colors fade.



An ideal poultry house is warm and dry in winter and easily opened to sun and air in summer

Concrete in Poultry Raising

THE floors and walls of a poultry house should be constructed of concrete.

The site for the poultry house should be upon dry soil. If it does not have a natural drainage, tile drainage should be installed. A gentle slope toward the south is desirable, and the house should have plenty of south windows so that the sunlight will be admitted during the greater part of the day. If a southern exposure is impossible, an eastern exposure is the next best.

A large amount of window space is desirable because sunlight is one of the most efficient germ destroyers. On the other hand, too much glass will result in making the house extremely hot in summer and cold in winter. The best system by which sufficient fresh air and sunlight can be secured is by the combined use of cloth and glass sash. Additional ventilation may be secured by the use of roof or wall ventilators. A good general rule is to have one square foot of window space for every ten square feet of floor space.

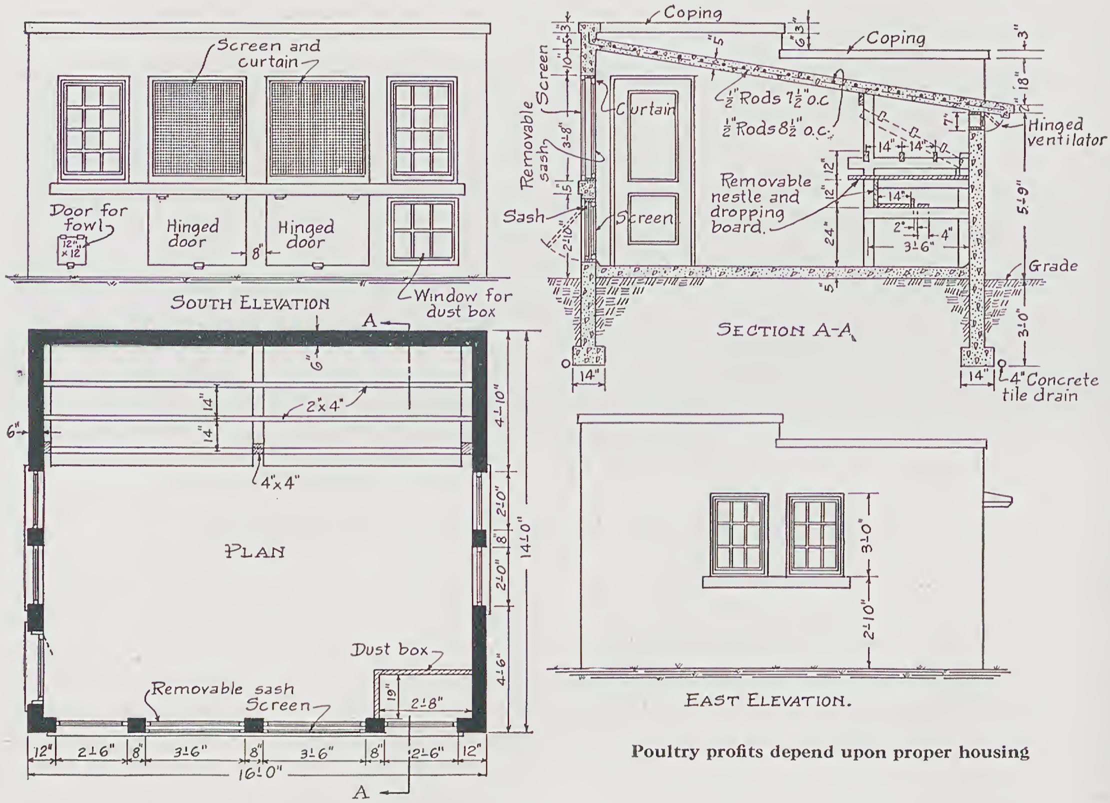
Walls should be made as smooth and free from projections as possible, to facilitate cleaning and disinfecting. Monolithic or concrete block walls can be made smooth if care is taken, so that no plaster or other finish will be necessary. An inside coat of whitewash is always helpful. Windows should be constructed so they will not accumulate litter.

The recommended sizes of poultry houses are given in bulletins issued by the various State Agricultural Experiment Stations. The space required per fowl decreases as the size of the house increases, and for this reason it is well to build the poultry house large. A pen 20 by 20 feet is large enough to accommodate 100 hens. They should have plenty of room to scratch and exercise properly, as this helps toward egg production. It is always safer to allow too much than too little floor space.

A concrete floor in combination with a concrete foundation makes the house sanitary, easy to keep clean, and keeps out rats and other marauding rodents. The floor should be high enough above the surface of the ground to prevent water running in from the outside. About three inches of sand or earth should be kept on the floor when in use, and this should be replaced often enough so that it will not become foul. Several inches of straw or chaff should be kept on top of the sand in order to make the fowls scratch for their food.

Fowls enjoy a sand wallow and it is also a help in keeping them free from lice. Such a wallow may be provided by curbing off a small space in one corner of the house and keeping it filled with sand. A small amount of coal ashes may be mixed with the sand, but the wallow should not be filled entirely with ashes because they absorb moisture too readily. The wallowing box should be cleaned frequently and the sand not allowed to become damp or filthy.

To facilitate the placing of wire fencing around the chicken run, concrete posts will be of advantage. Concrete feed containers will prove a very practical adjunct to the poultry house, protecting the grain from rats. A fresh supply of water can be made available by the use of concrete.



Poultry profits depend upon proper housing

POULTRY HOUSE
1 : 2 : 4 Mix

Footings	= 58 cu. ft.
Walls	= 283 cu. ft.
Floor	= 87 cu. ft.
Roof	= 108 cu. ft.
Total	536 cu. ft. or 20 cu. yds.

Material Required

Lehigh cement	= 30 bbls.
Sand	= 9 cu. yds.
Pebbles	= 18 cu. yds.

Reinforcing

44 ½″ round rods @ 18′ = 79.2 lin. ft. or 531 lbs.

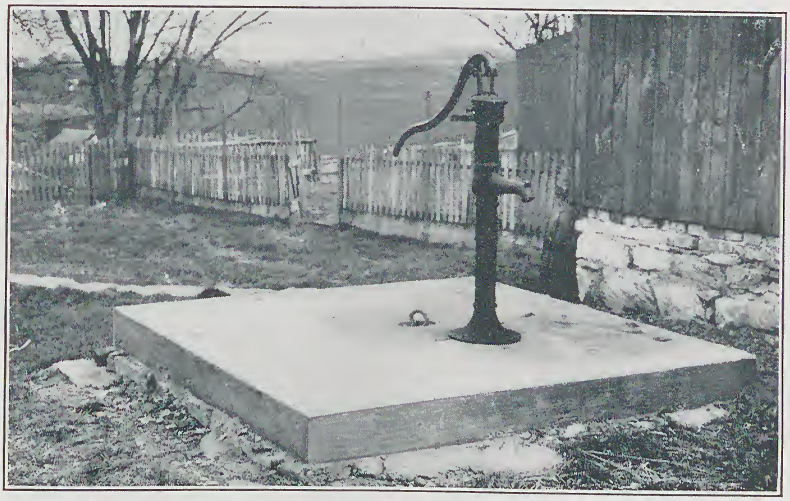
Well Covers and Linings

A CONCRETE well lining should extend into a well from six to eight feet below ground level, or to a sufficient depth to prevent animals from burrowing below it and to keep seepage of surface water out. When a new well is being built, it is desirable to line it with concrete from bottom to top. The work is thus finished for all time.

To apply lining to an old well, remove the cover and any existing lining to the depth at which it is proposed to place the concrete. At this place a platform must be built to form a stage on which to work. This may rest on the old lining or be supported against the soil. On this platform the forms for placing the concrete lining may be built. These should be one inch by four inch strips, beveled slightly at their edges, so that when tightly assembled, they will form practically a circle with tight joints. These boards should be braced with two by fours placed closely enough to provide sufficient strength to hold fresh concrete. A sketch on the following page shows essentials of construction.

As a rule, only interior forms will be needed if the old lining is carefully removed so that the earth back of it does not cave in. Concrete should be placed carefully so as not to knock down earth.

Forms should be left in place until the concrete has thoroughly hardened. Then they may be removed and the support or platform built for casting the concrete cover slab. Or if this is not so large as to be too heavy to be



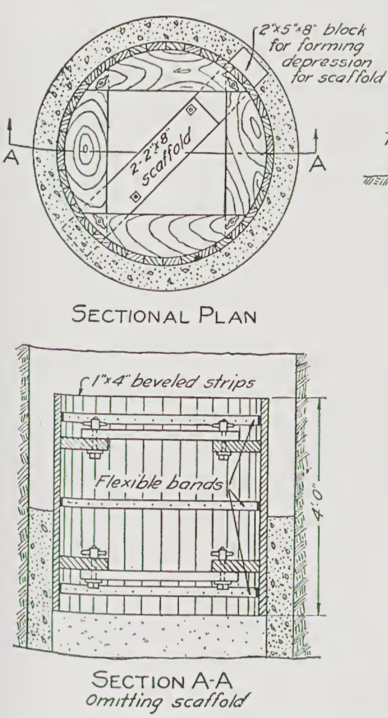
A concrete well cover is sanitary and serviceable

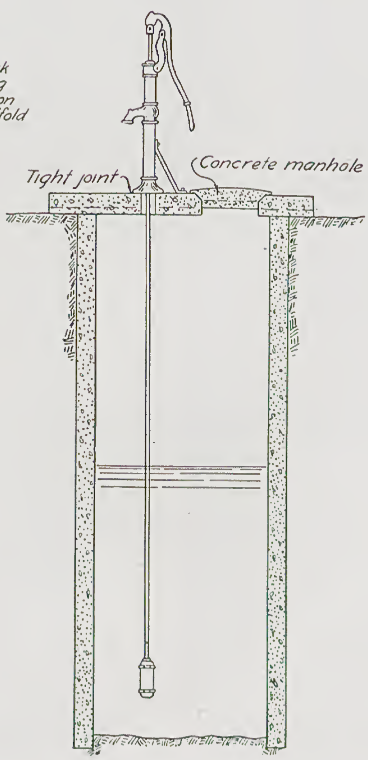
handled by two or three men it may be cast separately in a form made for that purpose, and when hardened, be rolled to its position over the well curb. The platform should be not less than four inches thick, reinforced with ¼-inch round rods placed eight or ten inches center to center and 1 inch from the bottom face.

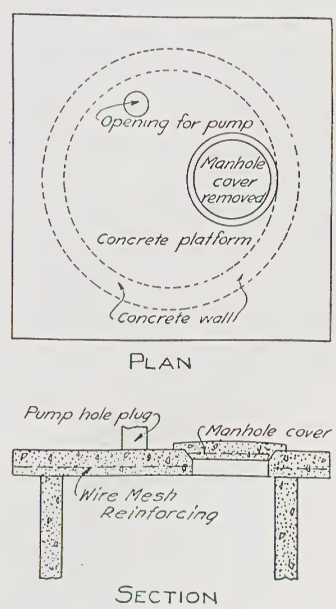
A small opening must be cast in the platform to permit passage of pump pipe and a larger one to serve as a manhole when the well has to be cleaned out. This manhole should have a tight-fitting concrete cover.

The reinforcement required for well platform and well walls depends entirely upon the size of the well. Great care should be taken to have the reinforcement thoroughly embedded to prevent rust due to dampness.

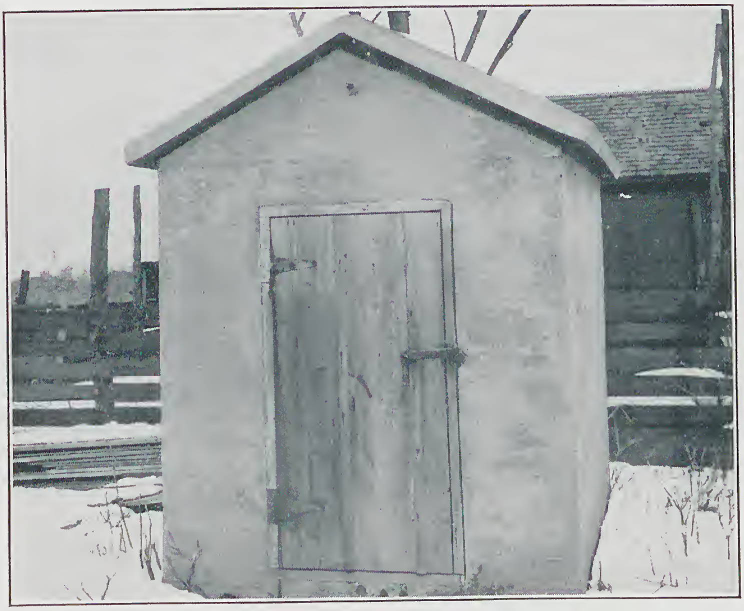
The construction is similar to that of an underground cistern, and the information on pages 112 and 113, under "Cisterns," may help in the building or the resurfacing of a well.







Detail of typical well lining and cover



Concrete is ideal for a smokehouse because it is fireproof and ratproof

Smokehouses

IT SEEMS ridiculous that farmers should produce all the meat used in the country and should then go to town and buy from the local butcher, at fancy retail prices, the meat which they raised and sold at wholesale. Every farmer, therefore, should have his own smokehouse for the curing of the home supply of meat.

Concrete is ideal for a smokehouse because it is fireproof and ratproof. The smokehouse may be either rectangular or circular. A circular structure is convenient if forms like those for building monolithic silos are available. A particular advantage of a circular structure is that distribution of smoke is more uniform than in a square structure. The fire-box should be located entirely outside of the smokehouse proper, to insure better regulation of fire and smoke control. Down draft into the flue leading to the center of the smokehouse reduces the draft somewhat and makes a denser smoke, which is the desired result. Dimensions of the house will vary in accordance with requirements. It is preferable to hang meat at least seven feet above the floor, for the double purpose of securing even smoking and to keep it away from extreme heat.

Concrete block may be used for building smokehouse walls, care being taken to lay block up with well-filled joints. No reinforcing will be required when eight-inch block are used for walls. A concrete smokehouse should not be used until the concrete is at least thirty days old, as heat from the fire will cause the concrete to dry out and become soft and crumbly.

SMOKEHOUSE—1 : 2 : 4 Mix

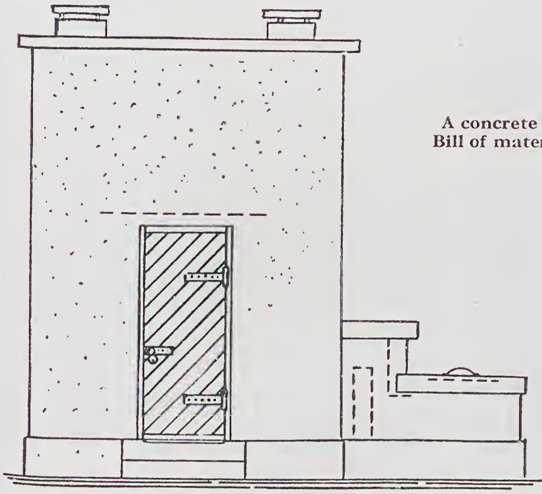
Wall	195 cu. ft.
Foundations	85 cu. ft.
Footing	51 cu. ft.
Footing	23 cu. ft.
Foundation	38 cu. ft.
Wall	46 cu. ft.
Floor	19 cu. ft.
Roof	30 cu. ft.
Roof	10 cu. ft.
	497 cu. ft. = 18.4 cu. yds.

Quantities of materials needed for concrete to build a smokehouse illustrated on page 125, 8′ 0″ × 9′ 0″ × 12′ 6″ high. For design of roof and reinforcement necessary see tabulation on pages 106 and 107

Material Required

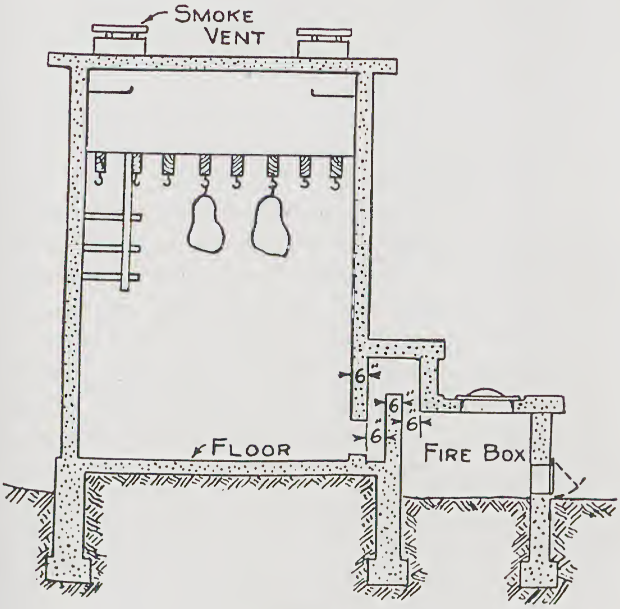
Lehigh cement	= 27 bbls.
Sand	= 8 cu. yds.
Pebbles	= 16 cu. yds.

A concrete smokehouse.
Bill of materials, page 124

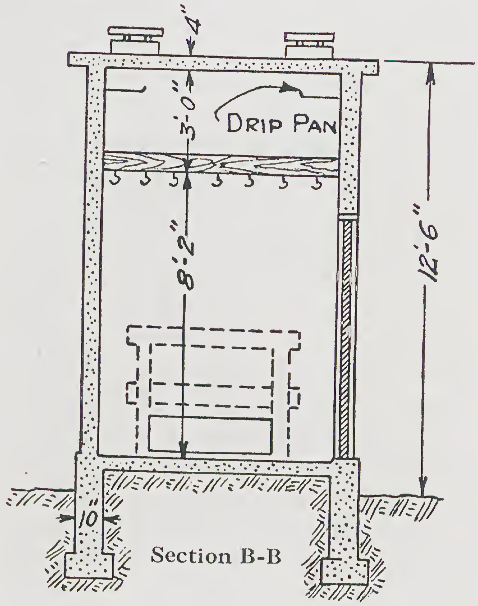


Side elevation

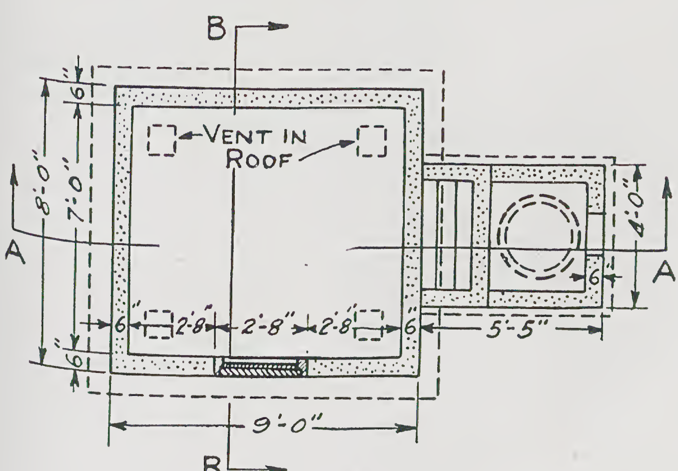
End elevation



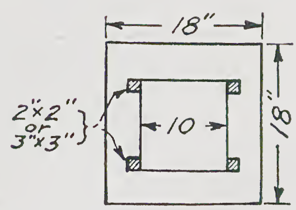
Section A-A



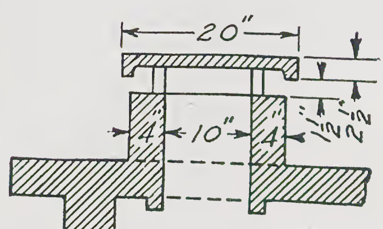
Section B-B



Plan



Top View of Ventilator with Cover Removed



Section

Detail of ventilator

The first consideration for profitable hog raising is sanitary quarters

Hog Raising

HOG houses should be located convenient to the hog lot for range where the animals are to exercise and also convenient to feeding facilities. Adjuncts to the hog house, all of which had best be built of concrete, are hog wallows, feeding floors, troughs, and watering tanks.

The feeding floor described under "Floors, Walks, and Pavements," pages 64 to 68, will be recognized as an easy piece of construction and of great value. The floors of the hog house should be graded toward drains to allow for flushing, as cleanliness is important.

Troughs and watering tanks with details of construction are explained on pages 93 to 96, under heading, "Troughs, Tanks, and Bins."

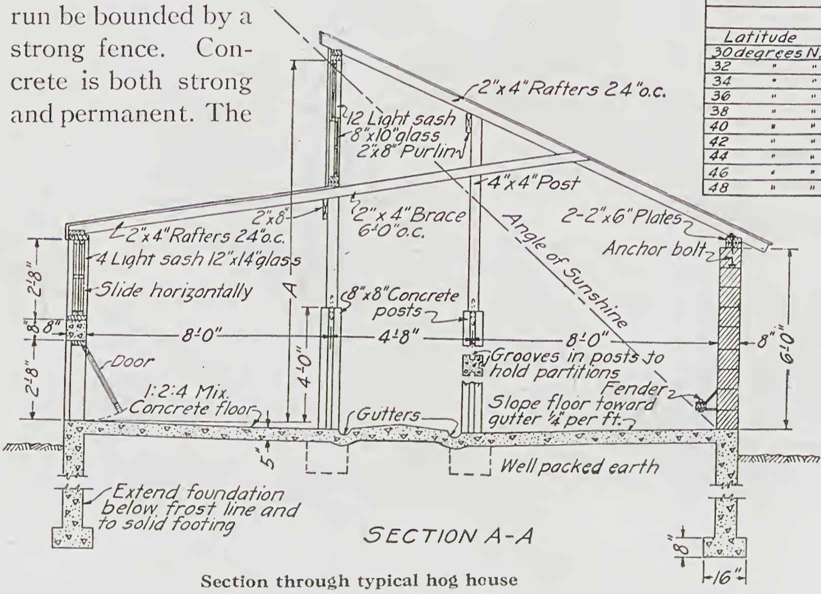
The tendency of hogs to rub themselves against their enclosures demands that the run be bounded by a strong fence. Concrete is both strong and permanent. The posts as well as rails should be constructed of concrete. See details under "Concrete Products," pages 76 to 92.

A concrete wallow is nothing but a tank of suitable size and depth to permit the animals to cool themselves in clean water. In addition, the tank may be made to serve dipping purposes in that germicidal solutions may be mixed with the water, or if in the form of oils, floated on its surface, and the hogs in using the wallow will take "their own medicine."

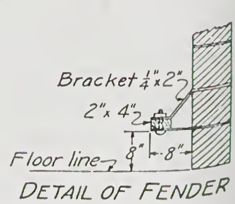
Hog houses and all of their accessories should be located with particular reference to a well-drained site. A hog house should face south

Table showing height to place windows. Distance A, for latitudes from 30 to 48 degrees N, and for farrowing periods from January to April.

DISTANCE A.				
Latitude	Jan. 1	Feb. 1	Mar. 1	April 1
30 degrees N.	9 ft. 0 in.	11 ft. 1 in.	15 ft. 6 in.	
32 " "	8 ft. 5 in.	10 ft. 4 in.	14 ft. 5 in.	
34 " "		9 ft. 8 in.	13 ft. 5 in.	
36 " "		9 ft. 0 in.	12 ft. 7 in.	
38 " "		8 ft. 4 in.	11 ft. 8 in.	
40 " "			10 ft. 11 in.	16 ft. 9 in.
42 " "			10 ft. 2 in.	15 ft. 7 in.
44 " "			9 ft. 6 in.	14 ft. 6 in.
46 " "			8 ft. 10 in.	13 ft. 6 in.
48 " "			8 ft. 2 in.	12 ft. 7 in.

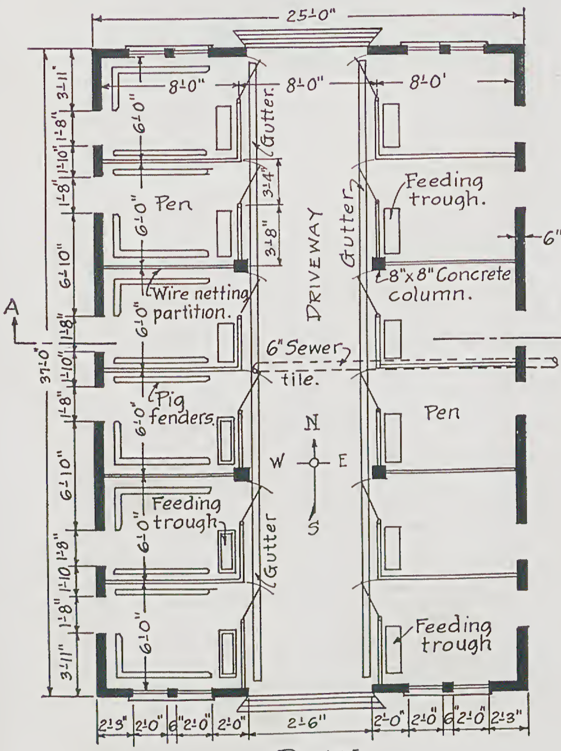


Section through typical hog house

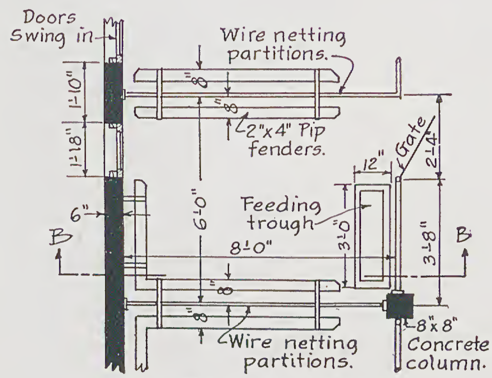


SECTION A-A.

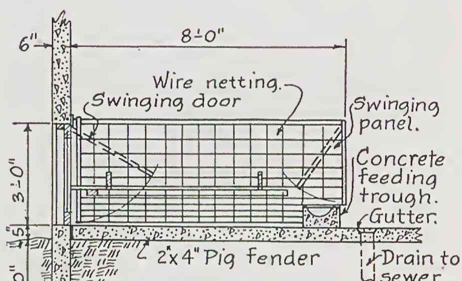
NORTH & SOUTH ELEVATION.



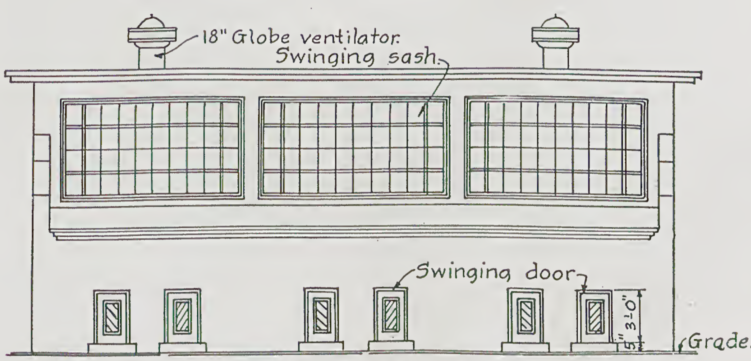
PLAN



TYPICAL LAYOUT OF PEN.

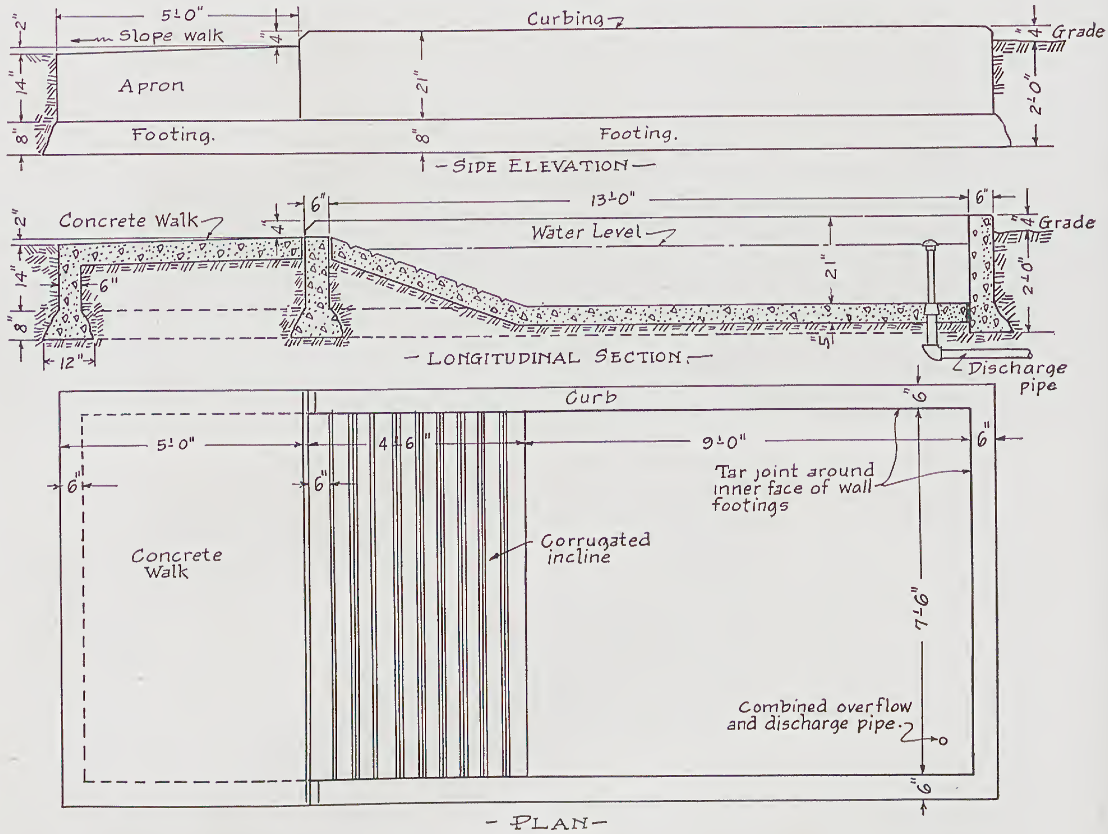


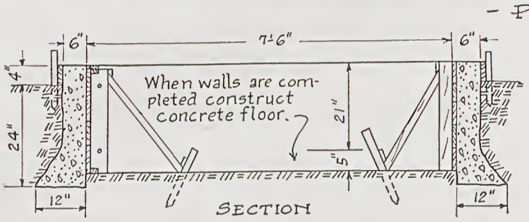
SECTION B-B.



EAST & WEST ELEVATION

A double house, such as shown here, should have its long way run north and south. So located, one row of pens receives light from the morning sun and the other from the afternoon sun, and sunlight is indispensable to sanitation



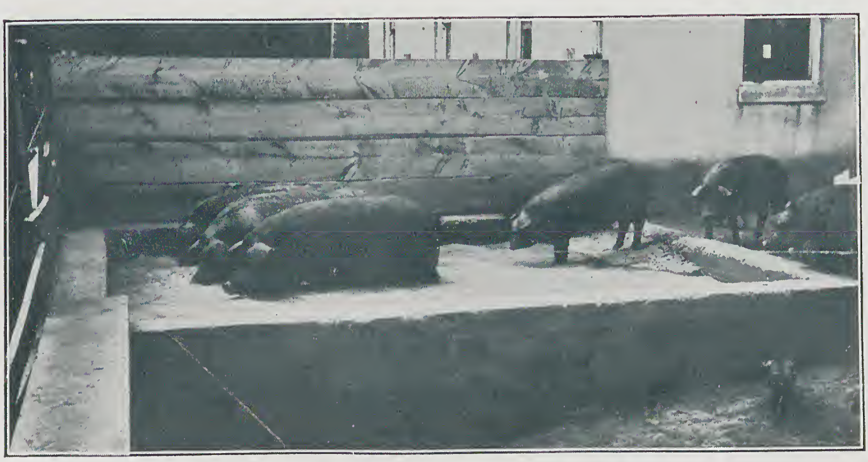


HOG WALLOW—1 : 2 : 3 Mix

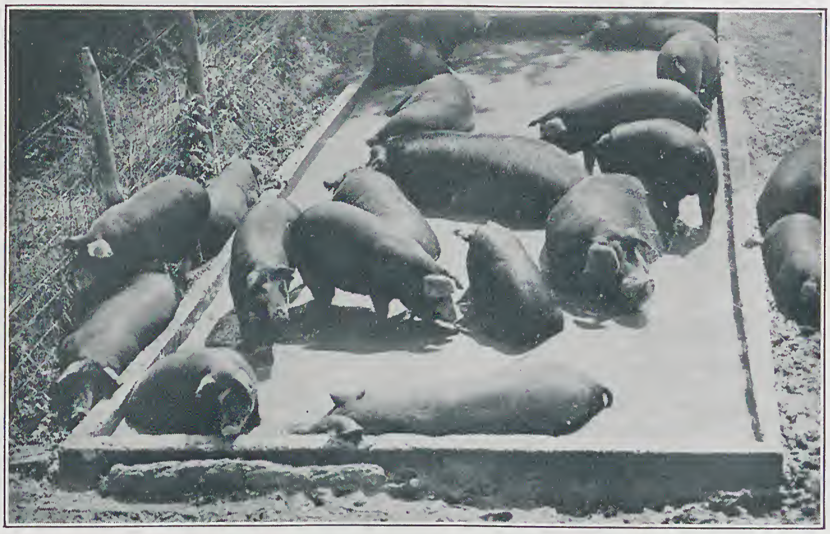
SIDE WALLS OF TANK 2.83′ × .5 × 13.5 × 2	= 34.00
END WALLS OF TANK .5 × 2.83 × 8.5 × 2	= 24.00
FLOOR OF TANK .41′ × 7.5′ × 14′	= 42.00
APPROACH SIDE AND END WALLS 2.15 × .5 × 17.5	= 22.00
APPROACH FLOOR .41 × 4.5 × 7.5	= 14.00
	136.00 cu. ft. = 5 cu. yds.

Material Required

Lehigh cement	= 9.0 bbls.
Sand	= 2.5 cu. yds.
Pebbles	= 4.0 cu. yds.



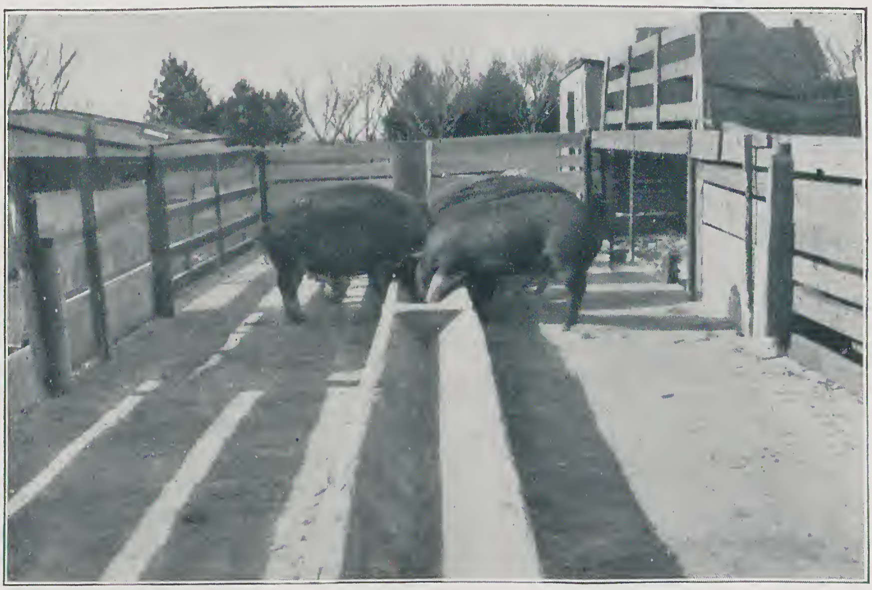
A concrete wallow is nothing but a tank of suitable size and depth to permit the animals to cool themselves in clean water



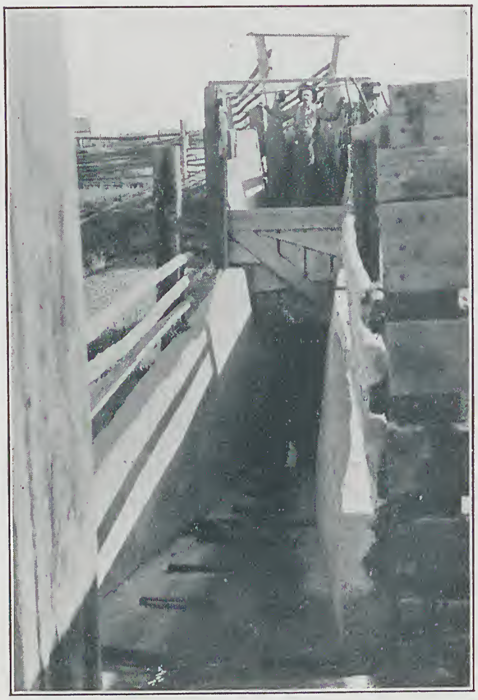
This evidence of hog contentment should forever silence the opinion that hogs prefer a mud hole to a clean concrete hog wallow

unless it is of the double monitor type, in which case its length should extend in a north and south direction, thus permitting one row of pens to get sunlight in the morning and the other in the afternoon. While concrete floors are not cold for stock if the animals are sufficiently bedded, hogs are a little more difficult to provide for in this way than other animals because of their tendency to disturb bedding placed for them, so it is well to build a removable slat floor in one corner, or at one side of each pen, for bedding quarters. If the hog house is of the monitor type, the passageway between rows of pens should be wide enough to serve as a driveway, in which case the concrete floor must be made thick enough to withstand the traffic of loaded wagons.

Concrete dipping vats need no care other than covering them up or so inclosing them that persons and animals cannot accidentally fall into them. Concrete is not injured by moisture. It will not rot or rust out. It requires no repairs. A concrete dipping vat, built of good materials and properly constructed, will always be ready for use and will prove a paying investment.



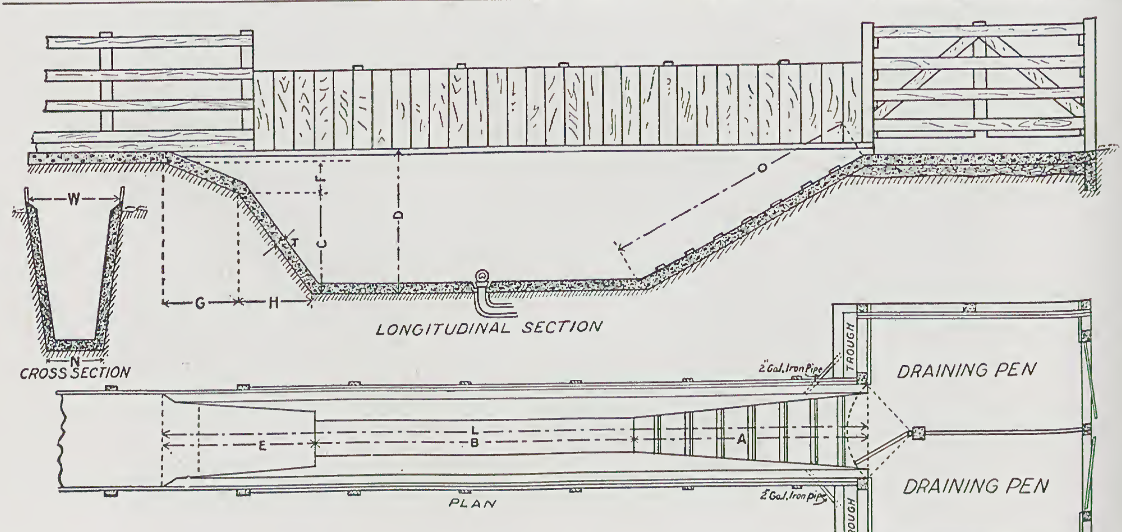
Concrete feeding troughs are a great aid in keeping the food from being spilled over the ground



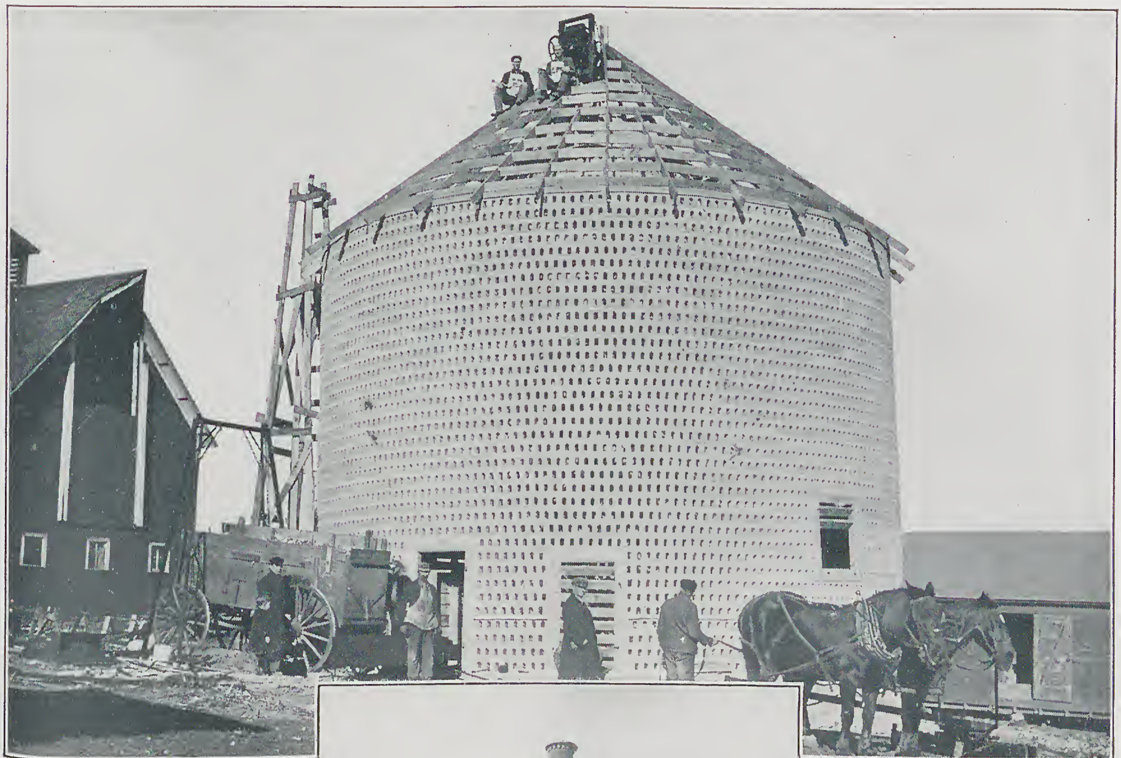
A concrete dipping vat

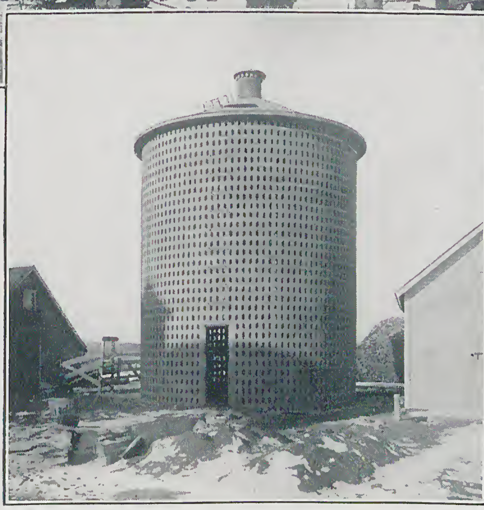
The dimensions of ground pits for dipping vats are shown in the following table, the letters at the heads of each column corresponding to those shown in design below.

Kind	W		N		D		L		E		B		A		G	
	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.
Horses	5	10	3	4	8	8	55	0	7	6	31	0	16	6	3	9
Cattle	5	4	3	4	7	8	51	0	6	8	31	0	13	4	3	4
Sheep	3	4	2	4	5	8	46	0	5	0	31	0	10	0	2	6
Hogs	3	4	2	4	5	8	36	0	5	0	31	0	10	0	2	6
	F		H		C		O		T		Lehigh		Sand		Stone	
	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Ft.	in.	Barrels		Cu. yds.		Cu. yds.	
Horses	2	2	3	9	3	9	18	7	0	8	43		13		26	
Cattle	1	11	3	4	3	4	15	4	0	8	37		11		22	
Sheep	1	5	2	6	2	6	11	6	0	8	24		7		14	
Hogs	1	5	2	6	2	6	11	6	0	8	19		5½		11	



Details of construction of a concrete dipping vat





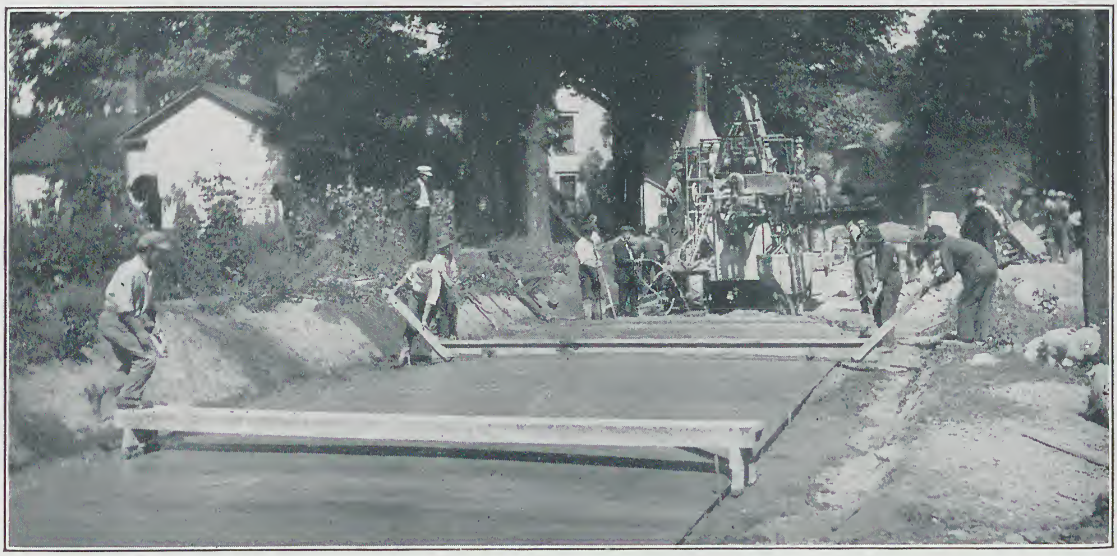
A typical concrete block corn crib

Construction details same as block silos

Corn Cribs

IT HAS been estimated that a rat will destroy or consume between $2 and $4 worth of grain each year if it has the opportunity. Rats have been effectively built out of corn cribs by using concrete. The most approved type of construction employs a block similar to those used in concrete block silos, the difference being that openings are cast into the block at the time it is made to provide ventilation. These openings are made rat and mouse proof by embedding wire mesh in the block when cast. Usually block corn cribs are built circular in form, and have at their center a flue or chimney connected with air inlets at the base to complete the ventilating system. Another type of concrete corn crib is built of special concrete stave also cast with openings to provide ventilation.

All doors should be wholly of metal or so protected by metal covering that rats cannot gnaw through. Corn cribs should have concrete floors raised sufficiently above ground level to prevent dampness. Floors should slope uniformly in one direction so that if rain blows into the openings during storms, water will drain out freely and quickly. Usually concrete corn cribs and concrete grain tanks are finished with metal roofs.



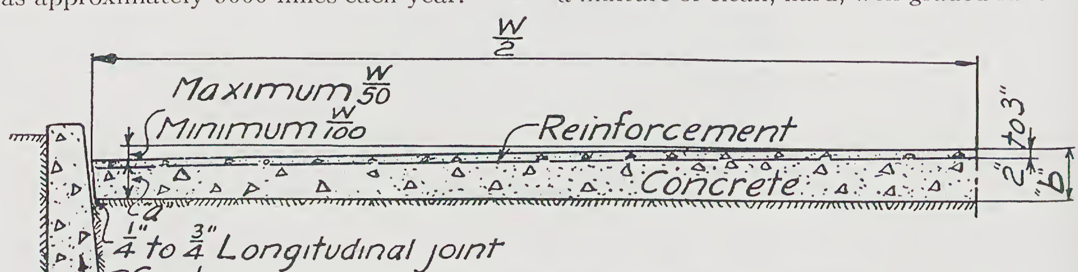
A concrete highway under construction

Construction of Highways

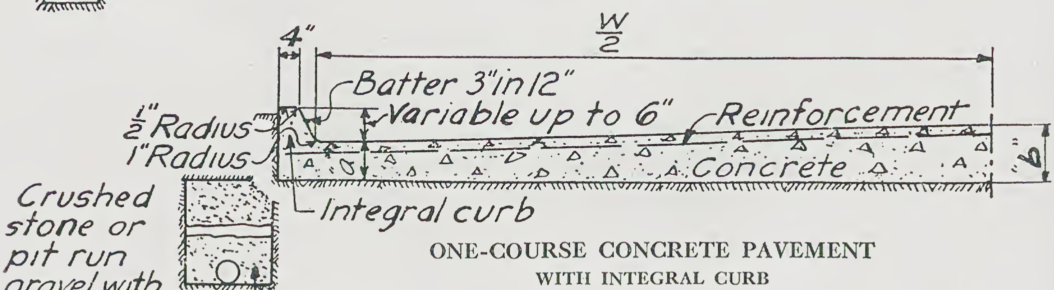
THE popularity of concrete as a highway paving material, and the evidence that time has proved its superior merits, are indicated by the following figures. Total yardage of all kind of concrete highway pavement—roads, streets, and alleys—at the end of 1908 was slightly less than 600,000 square yards. At the end of 1921 the total was close to 275,000,000 square yards. During 1919, 1920, and 1921 the concrete highway pavement, built on the basis of an average width of 18 feet, was approximately 5000 miles each year.

In every state in the Union there are concrete roads. Cities in every state of the Union have concrete streets, and probably the same is true with respect to concrete alleys, since in many cases alleys are referred to as driveways. In the following the term highway pavement will be considered as applying to roads, streets, and alleys, except where otherwise noted.

As a rule, most concrete highway pavements are of one-course construction. A concrete highway pavement—road, street, or alley—is a mixture of clean, hard, well-graded sand and



ONE-COURSE CONCRETE PAVEMENT
WITH SEPARATE CURB



ONE-COURSE CONCRETE PAVEMENT
WITH INTEGRAL CURB

Note: "W" denotes width of pavement

"a" = not less than 6"
"b" = not less than "a" + 2"

Improved methods of road building are developing new types of machinery

pebbles or broken stone combined with Portland cement and water, all of the ingredients being thoroughly mixed and then placed on a properly prepared subgrade to a thickness of seven inches or more, so as to form slabs the width of the road and 30 feet or more long. The result is a rigid, unyielding, durable pavement, with non-skid surface, that is usable every day of the year, regardless of weather.

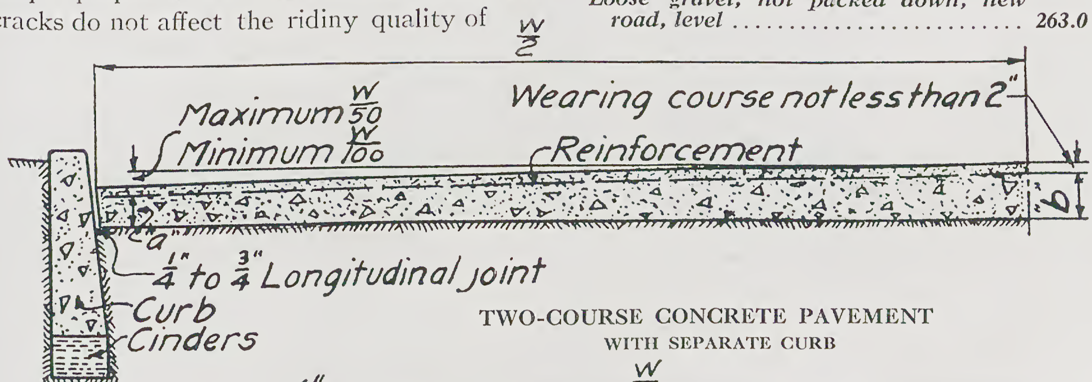
Concrete roads built in 1909 are still giving good service.

Concrete highway pavements are often the subject of much adverse criticism because some of them have cracked. Most of this cracking has been due to insufficient drainage or to improper preparation of the subbase. Although cracks do not affect the riding quality of the road nor, if kept filled with tar and coarse sand, have they any effect upon the durability of the pavement, they are unsightly and can be avoided by proper construction methods.

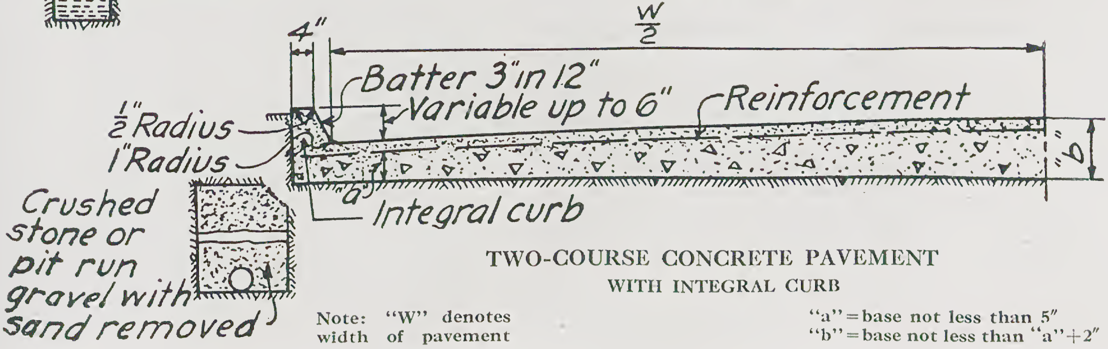
The following table shows the results of a series of tests made to determine the tractive resistance of concrete highways:

PULL IN POUNDS PER TON

Over a level, unsurfaced concrete	***27.6***
Concrete base, ⅜-inch skin top asphaltic oil and screenings	49.2
Waterbound macadam, level, good condition	64.3
Concrete base, ½-inch Topeka top, level, good condition	68.5
Gravel road, good condition, level	78.2
Earth road, fine dust, level	92.0
Earth road, stiff mud on top, firm underneath, level	218.0
Loose gravel, not packed down, new road, level	***263.0***



TWO-COURSE CONCRETE PAVEMENT
WITH SEPARATE CURB

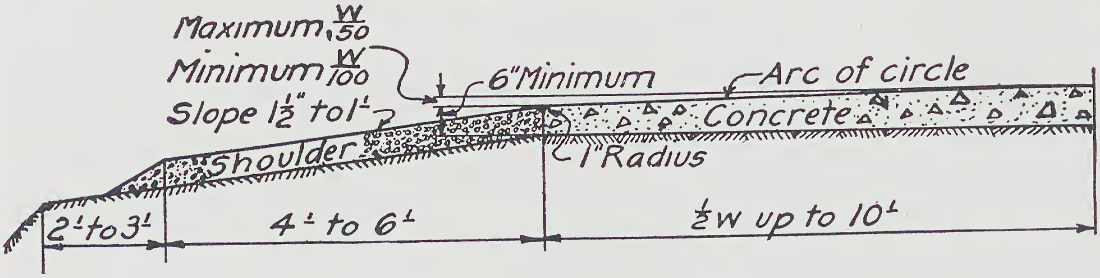


TWO-COURSE CONCRETE PAVEMENT
WITH INTEGRAL CURB

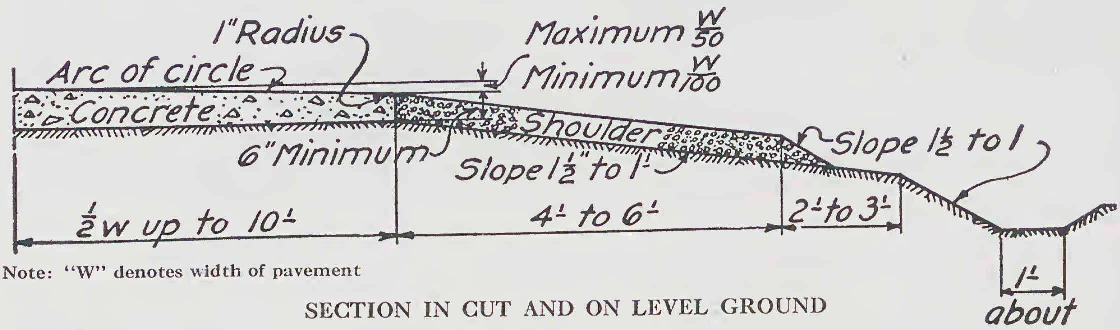
Note: "W" denotes width of pavement

"a" = base not less than 5"
"b" = base not less than "a"+2"

ONE-COURSE CONCRETE HIGHWAY



SECTION ON FILL



Note: "W" denotes width of pavement

SECTION IN CUT AND ON LEVEL GROUND

Another and later series of tests were made on various types of highways to prove the low tractive resistance of concrete on the basis of gasoline consumption. Five two-ton trucks were used and runs were made over sections of paved and unpaved roads. The average mileage per gallon of gasoline used, with the trucks loaded to capacity, is summarized in the following table:

Earth	***5.78 miles per gallon***
Fair gravel	7.19 miles per gallon
Good gravel	9.39 miles per gallon
Fair bituminous macadam	9.48 miles per gallon
Fair brick	9.88 miles per gallon
Good brick	11.44 miles per gallon
Concrete	***11.78 miles per gallon***

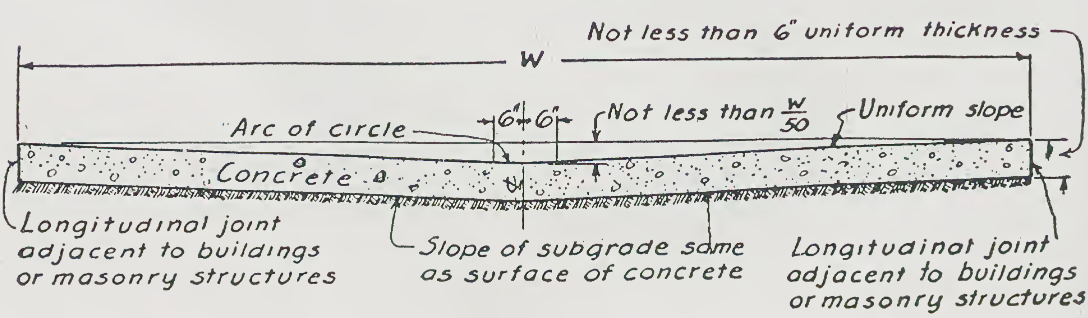
In other words, more than double the mileage was obtained on concrete as was obtained on earth the same quantity of gasoline being used.

The non-skid surface of a correctly constructed concrete highway makes it the safest type for both horse-drawn and motor vehicles.

The fundamental requirements demanded for the satisfactory concrete highway are underdrainage—preparation of subbase, selection of materials—thorough mixing, careful placing and curing. These, with efficient engineering and careful supervision, will give a permanent and safe highway.

Concrete highway pavements are both plain and reinforced. Reinforcement is particularly recommended where the concrete is laid upon a subbase such as a fill that may not have attained maximum settlement and across other

ONE-COURSE CONCRETE ALLEY



CROSS-SECTION

Note: "W" denotes width of pavement

unstable spots. It seems particularly effective also in preventing cracks which may occur in the pavement from opening to any considerable extent. Opinions as to the desirability of reinforced pavement as against unreinforced pavement thick enough to produce corresponding strength are still at variance, although the trend of the times is indicated in the present practice of the Pennsylvania State Highway Department, which requires that all concrete roads shall be reinforced.

Demand for utmost safety to traffic has resulted in more attention being given to details of design and construction. Among these are easier curves, superelevated and widened so that motor vehicles can take them in safety without unnecessary reduction of speed. In general, the tendency is toward wider roads, 18 feet being the minimum recommended for average highways.

In certain cases roads as well as streets are bordered by curbs where curves are sharp, and through cuts where the pavement surface serves also to drain the cut, as the curb helps form a gutter and thus prevents washing of soil at pavement edges.

Concrete roads and streets are slightly crowned at their center to drain surface water from rains quickly. The crown is so slight that traffic uses the entire surface with equal facility. Concrete alleys are sometimes crowned at the center, although, where the gradient and permanent structures bordering an alley permit it, the surface is usually dished, that is, it is lower at the center than at the sides, and the pavement therefore acts as a gutter to carry water to sewer mains.

The tendency during the past year or two has been to increase the thickness of concrete pavements, and to use richer mixtures than were common to early practice. Many improvements have been made in the methods of handling materials and organizing construction gangs. Finishing machines have largely replaced hand labor.

Fundamental principles, on pages 153 to 185, give valuable information which is applicable to highway construction.

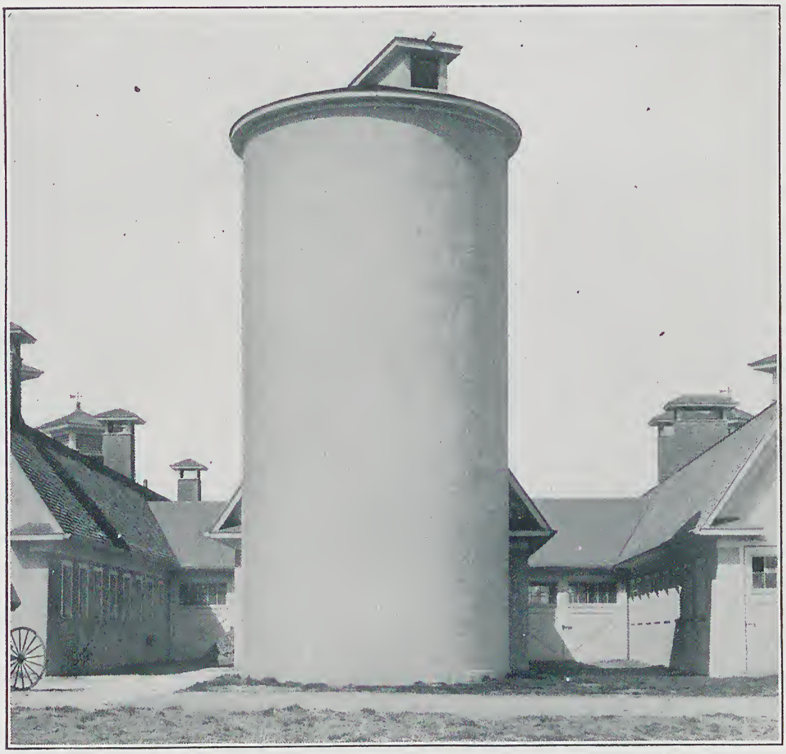
The table below gives quantities of materials required for concrete pavements of various widths and thicknesses per linear foot and square yards of surface:

Area of Cross-section, Cubic Yards, Quantities* of Materials Required Per Linear Foot, and Square Yards of Surface for Concrete Roads for Various Widths and Thicknesses Shown

Width Feet	Thickness			Area of Cross-section Square Feet	Cubic Yards Concrete per Linear Foot of Pavement	Square Yards per Mile	Lehigh Cement Barrels		Sand, Cubic Yards		Rock or Pebbles Cubic Yards	
	Sides Inches	Center Inches	Average Inches				1:2:3	1:1½:3	1:2:3	1:1½:3	1:2:3	1:1½:3
9	6	8	7.333	5.500	.204	5,280	.355	.389	.106	.086	.157	.173
10	6	8	7.333	6.111	.227	5,867	.394	.433	.118	.095	.175	.193
18	6	8	7.333	11.000	.407	10,560	.708	.777	.212	.171	.313	.346
18	7	9	8.333	12.500	.463	10,560	.806	.884	.241	.194	.357	.324
18	8	10	9.333	14.000	.519	10,560	.903	.991	.270	.218	.400	.441
20	6	8	7.333	12.222	.453	11,733	.788	.866	.235	.190	.349	.385
20	7	9	8.333	13.777	.510	11,733	.887	.974	.265	.214	.393	.434
20	8	10	9.333	15.555	.576	11,733	1.002	1.100	.300	.242	.444	.490
24	6	8	7.333	14.667	.543	14,080	.945	1.037	.282	.228	.418	.462
24	7	9	8.333	16.667	.617	14,080	1.074	1.178	.321	.259	.475	.524
24	8	10	9.333	18.667	.691	14,080	1.202	1.320	.359	.290	.532	.587
26	6	8½	7.667	16.611	.615	15,253	1.070	1.175	.320	.258	.474	.523
26	7	9½	8.667	18.777	.695	15,253	1.208	1.327	.361	.292	.535	.591
26	8	10½	9.667	20.944	.776	15,253	1.350	1.482	.404	.326	.598	.660
27	6	9	8.000	18.000	.667	15,840	1.161	1.274	.347	.280	.514	.567
27	8	11	10.000	22.500	.833	15,840	1.449	1.591	.433	.350	.641	.708
30	6	9	8.000	20.000	.741	17,600	1.289	1.415	.385	.311	.571	.630
30	8	11	10.000	25.000	.926	17,600	1.611	1.769	.482	.389	.713	.787
36	6	9½	8.333	25.000	.926	21,120	1.611	1.769	.482	.389	.713	.787
36	8	11½	10.333	31.000	1.148	21,120	1.998	2.193	.597	.482	.884	.976
40	6	10	8.667	28.888	1.070	23,467	1.862	2.044	.556	.449	.824	.910
40	8	12	10.667	35.555	1.317	23,467	2.292	2.515	.685	.553	1.014	1.119

Lehigh cement for 1 cu. yd. concrete: 1:1½:3 Mix: 1.91 bbls.; 1:2:3 Mix: 1.74 bbls.
Sand for 1 cu. yd. concrete: 1:1½:3 Mix: 0.42 cu. yd.; 1:2:3 Mix: 0.52 cu. yd.
Stone for 1 cu. yd. concrete: 1:1½:3 Mix: 0.85 cu. yd.; 1:2:3 Mix: 0.77 cu. yd.

* Based on 1 bbl. Lehigh cement equals 4 cu. ft.: voids in stone, 45 per cent. From Taylor and Thompson, "Concrete, Plain and Reinforced."



The monolithic concrete structure fulfils all requirements of an ideal silo

Concrete Silos

SILOS are universally circular in form. For such structures concrete may be used in any one of three ways, monolithic, concrete block, and concrete stave. Each particular type of concrete silo will do all that a silo is intended to do, each combines all requirements in a degree exceeding any other class of construction, and each has its advocates.

Silos must be air-tight, watertight, strong, durable, require little or no maintenance, have smooth interior walls, and be permanent. If the proper method of construction has been followed, the silo will be fireproof. No quality is more desirable than fireproofness when it is considered that the silo usually contains a complete season's crop of feed.

Some types of silos other than concrete are a continual expense. When empty, they are likely to blow down because they lack the weight necessary to stability.

Many farmers have put up their own concrete silos, using one of the three types of construction mentioned. For monolithic construction, special circular steel forms should be provided because the cost and labor of making wood forms are seldom justified for a single structure.

Few farmers are warranted in investing in a set of commercial forms since one silo is usually sufficient on the average farm. However, farmers of a community have been known to join in buying a set of commercial forms and hiring them out to one another in the same manner that community mixers have been purchased and used. Certain equipment besides the forms is necessary.

It is better to engage an experienced contractor who specializes in the building of silos to move his outfit to the farm and put up the structure.

The silo should be located where it will serve the greatest convenience in feeding operations. At one end of the barn or at the middle of one side is a good location. The structure is usually connected to the barn by a short covered passageway.

The tables on the following pages show various data relative to capacity of silos required to meet different feeding conditions, quantity of silage, reinforcement, quantity of materials, etc. These will be found very useful for reference when deciding upon the size structure to build.

DIAMETER OF SILO REQUIRED TO FEED VARIOUS NUMBERS OF ANIMALS

Diameter in Feet	Approximate Minimum Pounds to be Fed Daily	Minimum Number of Each Kind of Stock to be Fed from Each Size Silo					
		Dairy Cows	Beef Cattle	Stock Cattle	500-lb. Calves	Horses	Sheep
10	525	13	21	26	44	48	175
12	755	19	30	38	63	69	252
14	1030	26	41	52	86	94	344
16	1340	34	54	67	112	122	446
18	1700	42	68	85	142	155	567
20	2100	53	84	105	175	191	700

APPROXIMATE CAPACITY OF ROUND SILOS

Height of Silo Feet	Inside Diameter of Silo in Feet and Capacity in Tons					
	10 Feet	12 Feet	14 Feet	16 Feet	18 Feet	20 Feet
	Tons	Tons	Tons	Tons	Tons	Tons
28	42	61	83	..	..	..
30	47	67	91	..	..	..
32	51	74	100	131	..	..
34	56	80	109	143	..	..
36	61	87	118	155	196	..
38	66	94	128	167	212	..
40	70	101	138	180	229	280
42	..	109	148	193	244	299
44	..	117	159	207	261	320
46	..	..	170	222	277	340
48	..	..	..	236	293	361
50	..	..	..	..	310	382

QUANTITY OF SILAGE REQUIRED AND ECONOMICAL DIAMETER OF SILO FOR THE DAIRY HERD

Number of Dairy Cows in Herd	Feed for 180 Days			Feed for 240 Days		
	Estimated Tonnage of Silage Consumed	Size of Silo		Estimated Tonnage of Silage Consumed	Size of Silo	
		Diameter	Height		Diameter	Height
	Tons	Feet	Feet	Tons	Feet	Feet
13	47	10	30	63	10	36
15	54	10	33	72	10	40
20	72	12	32	96	12	39
25	90	12	37	123	14	37
30	108	14	34	144	14	42
35	126	14	38	168	16	37
40	144	16	35	192	16	42
45	162	16	37	216	18	39
50	180	16	40	240	18	42
60	216	18	39	288	20	41
70	252	18	41	336	20	46

QUANTITY OF CONCRETE MATERIALS FOR MONOLITHIC SILOS OF VARIOUS DIAMETERS

These figures include footings and floor, but not roof. Walls 6 inches thick. Continuous doors 2 feet wide. Figures are for sacks of cement and cubic yards of sand and pebbles

Inside Diameter	For Silo 30 Feet High			For Each Additional 5 Feet in Height		
	Lehigh Cement	Sand	Pebbles or Stone	Lehigh Cement	Sand	Pebbles or Stone
Feet	Sacks	Cu. Yds.	Cu. Yds.	Sacks	Cu. Yds.	Cu. Yds.
10	116	11.0	18.0	16.0	1.5	2.4
12	140	13.0	21.5	19.2	1.8	2.9
14	164	15.0	25.0	22.5	2.1	3.4
16	188	17.3	28.7	25.7	2.4	3.8
18	212	19.6	32.6	29.0	2.7	4.3
20	236	22.0	36.5	32.3	3.0	4.8

SPACING OF HORIZONTAL REINFORCING RODS FOR SILOS OF VARIOUS INSIDE DIAMETERS

Distance in Feet Down from Top of Silo	10-foot Diameter ⅜-inch Round Rods*	12-foot Diameter ⅜-inch Round Rods*	14-foot Diameter ½-inch Round Rods*	16-foot Diameter ½-inch Round Rods*	18-foot Diameter ½-inch Round Rods*	20-foot Diameter ½-inch Round Rods*
	Inches	Inches	Inches	Inches	Inches	Inches
Top 5 ft.	24	24	24	24	24	24
5 to 10	24	24	24	24	24	24
10 to 15	24	18	24	24	24	24
15 to 20	18	16	24	18	18	16
20 to 25	16	12	18	16	14	14
25 to 30	14	10	16	14	12	12
30 to 35	12	9	14	12	10	10
35 to 40	10	8	12	10	9	8
40 to 45	9	7	11	9	8	7½
45 to 50	8	6½	10	8½	7½	7

* If square rods are used, increase spacing 30 per cent, but in no case should spacing be greater than 24 inches.

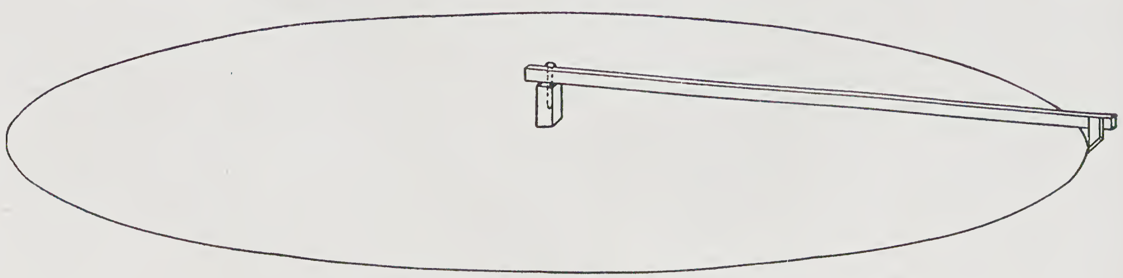
TRIANGLE MESH REINFORCEMENT

Distance in Feet from Top	Inside Diameter of Silo											
	10 Feet		12 Feet		14 Feet		16 Feet		18 Feet		20 Feet	
	Layers	Style No.	Layers	Style No.	Layers	Style No.	Layers	Style No.	Layers	Style No.	Layers	Style No.
0 to 15	1	093	1	093	1	093	1	093	1	093	1	093
15 to 18	1	093	1	093	1	093	1	093	1	093	1	126
18 to 21	1	093	1	093	1	093	1	126	1	126	1	126
21 to 24	1	093	1	093	1	126	1	126	1	126	2	093
24 to 27	1	093	1	093	1	126	1	126	2	093	2	093
27 to 30	1	093	1	126	1	126	2	093	2	093	2	093
30 to 33	1	093	1	126	2	093	2	093	2	093	1 each	093 & 126
33 to 36	1	126	1	126	2	093	2	093	1 each	093 & 126	1 each	093 & 126
36 to 39	1	126	2	093	2	093	2	093	1 each	093 & 126	2	126
39 to 42	1	126	2	093	2	093	1 each	093 & 126	2	126	2	126
42 to 45	1	126	2	093	1 each	093 & 126	1 each	093 & 126	2	126	2	146
45 to 48	2	093	2	093	1 each	093 & 126	2	126	2	146	2	146
48 to 50	2	093	2	093	1 each	093 & 126	2	126	2	146	2	146

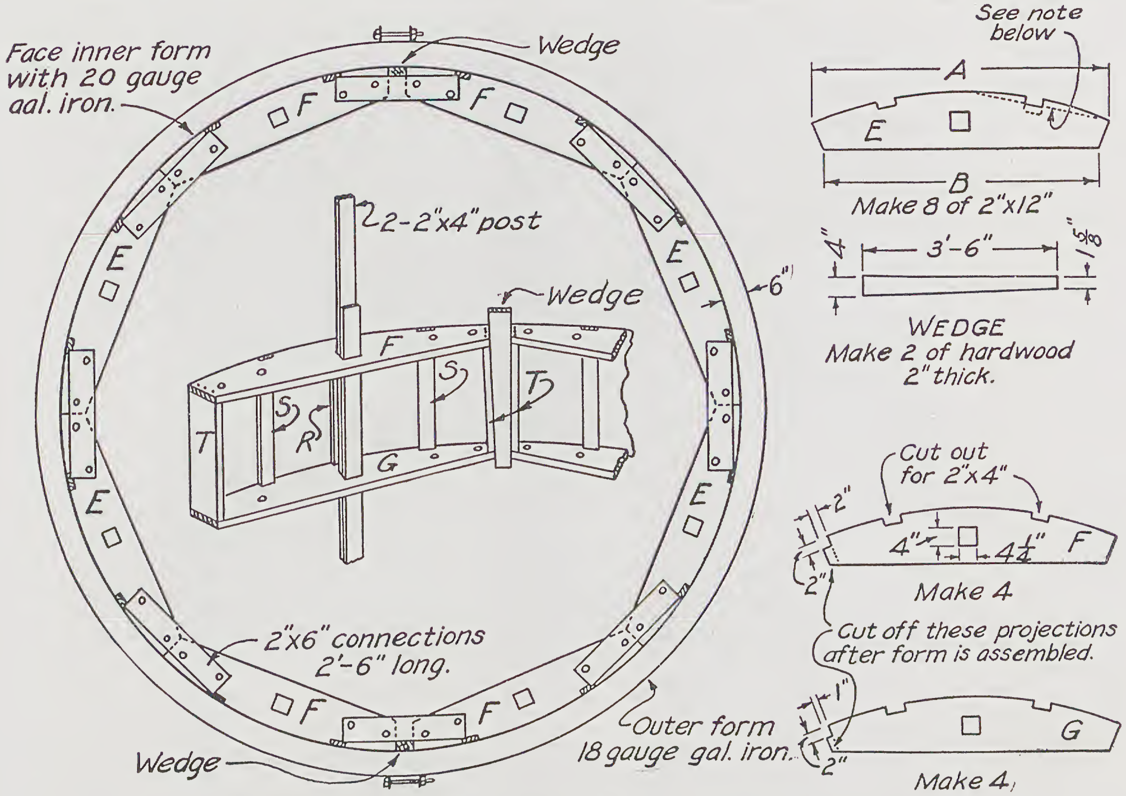
Note: Style No. 093 has number 6 wires spaced 4 inches apart; Style No. 126 has number 4 wires spaced 4 inches apart; Style No. 146 has number 3 wires spaced 4 inches apart.

The notes which follow are intended as a guide to important requirements of construction, thus enabling the farmer to act as inspector on the job, rather than to qualify him for doing the actual work himself.

After a circle corresponding to the outside diameter of the silo has been laid out on the ground, as shown below, the area thus enclosed should be excavated four or five feet so that the floor or bottom of the silo will be about



Arrangement of sweep for laying out silo forms



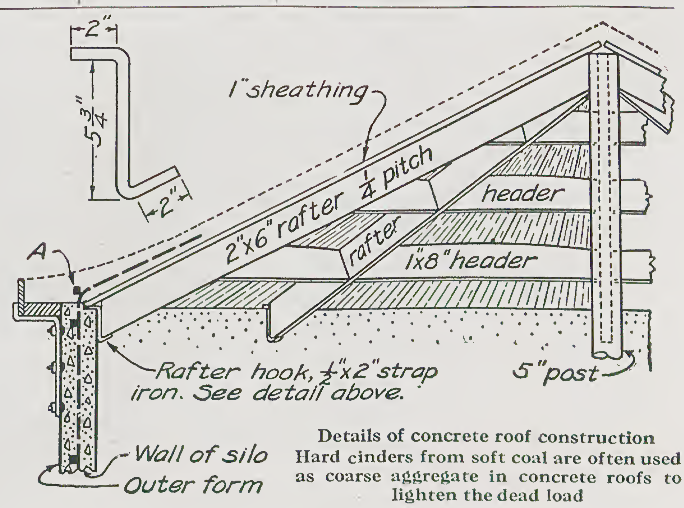
Details of silo forms that can be made by any handy man around the farm
Note: If intermittent doors are to be used, trim two ribs *E* on dotted line
Use 2 x 6 inch studding for pieces *T*. Pieces *S* and *R* are made of 2 x 4 inch studding
Pieces *S* are set into the ribs and pieces *T* and *R* are nailed between them

DIMENSIONS OF INNER AND OUTER FORM SECTIONS

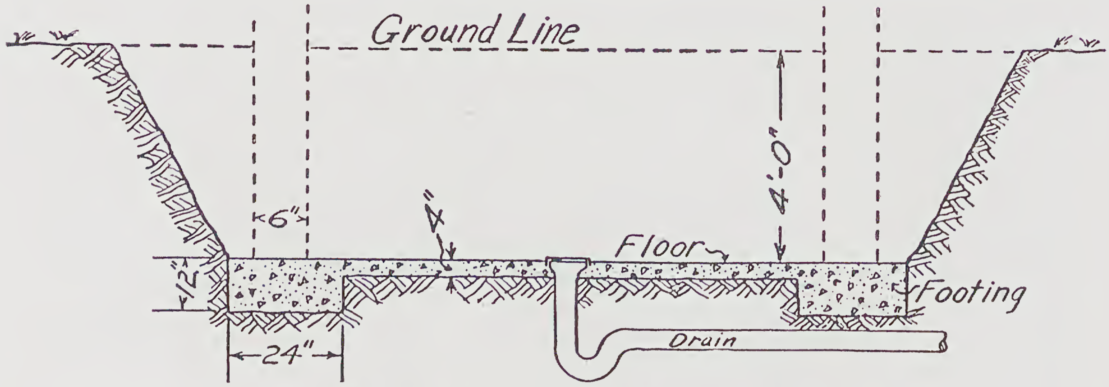
Inside Diameter of Silo	Inner Form				Outer Form
	Number of Sections in Inner Form	Length A	Length B	20 Gauge Gal. Iron 36 in. wide, Length of Each Piece	18 Gauge Gal. Iron 36 in. wide, 2 Pcs., Length of Each Piece
10 ft.	6	5'– 0"	4'– 7½"	5'–2¾"	18'– 3"
12 ft.	8	4'– 6¾"	4'– 1½"	4'–8½"	21'– 5"
14 ft.	8	5'– 4"	4'–11½"	5'–6"	24'– 7"
16 ft.	8	6'– 1"	5'– 9½"	6'–3"	27'– 9"
18 ft.	8	6'–10½"	6'– 7½"	7'–0¾"	30'–10½"
20 ft.	10	6'– 2"	5'–10"	6'–3"	34'– 0"

Material for 14-Foot Silo Form

5 pieces 2 by 12 by 16 feet, for ribs
1 piece 2 by 12 by 6 feet, for ribs
4 pieces 2 by 6 by 12 feet, for studding
6 pieces 2 by 4 by 12 feet, for studding
4 pieces 2 by 6 by 10 feet, for connections
3 pieces 2 by 6 by 8 feet, for continuous door form
2 pieces 2 by 2 by 8 feet, for continuous door form
64 carriage bolts, ½ inch by 4½ inches
2 pieces 18 gauge galvanized iron 3 feet wide, 24 feet 7 inches long
8 pieces 20 gauge galvanized iron 3 feet wide, 5 feet 6 inches long
Nails, rivets, lugs, hooks, wedges, etc.



Details of concrete roof construction
Hard cinders from soft coal are often used as coarse aggregate in concrete roofs to lighten the dead load



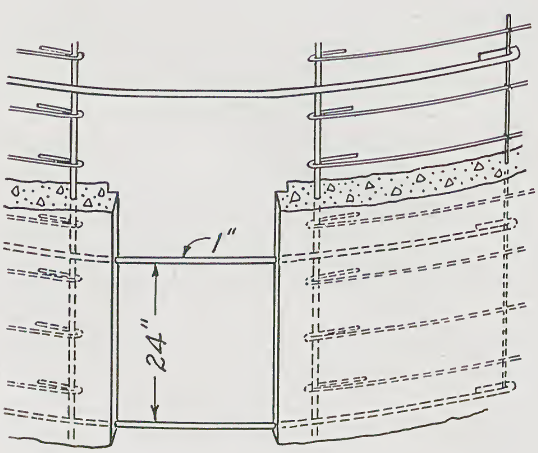
Foundation pit for silo, showing floor and drain

that distance below ground level. This will reduce the height of the silo above ground. It makes the distance shorter for blowing the cut silage when filling the structure, and the distance below ground level is not too great to permit throwing out the last silage for feeding. It also insures that the foundation will start below possible frost penetration.

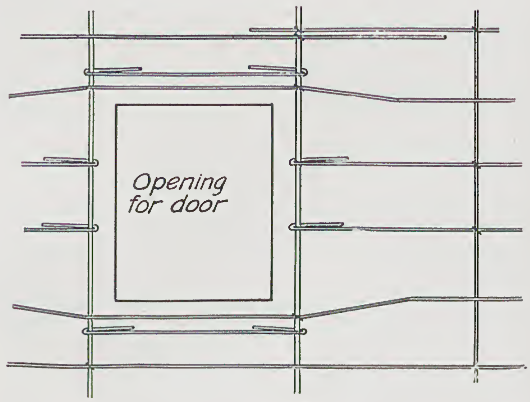
At the center of the floor a drain should be set to connect with a line of tile to lead away surplus liquids from the silage (illustrated at top of page). Too great an accumulation of such liquid in the silo may develop bursting pressure greater than the silo may be able to stand. The drain should be trapped so as to prevent air from entering. If the ground where the silo is built is not perfectly firm so as to insure stability of foundation, it is well to start the walls on a footing three or four feet wide, reinforced with ⅜-inch steel rods 30 or 40 inches long, depending upon footing width. This forms a sort of a mattress, so to speak, that will evenly distribute the load of the structure and its contents over a sufficient area of soil to insure stability. Concrete in the footing should be allowed to harden for twenty-four hours at least before starting the side walls, and before these are started the floors should have been laid. (See table of mixtures on page 157 for recognized mixtures for various parts of silos.) Two types of doorways are used for silos, intermittent and continuous. Either type will do, and it is largely a matter of individual preference. The commercial silo forms used to-day provide for doorway openings as concreting progresses, and also permit building a chute monolithic with the silo if such is desired. A chute makes it easy to throw silage down for feeding without it scattering all over the ground, particularly on windy days.

Reinforcement for Silos

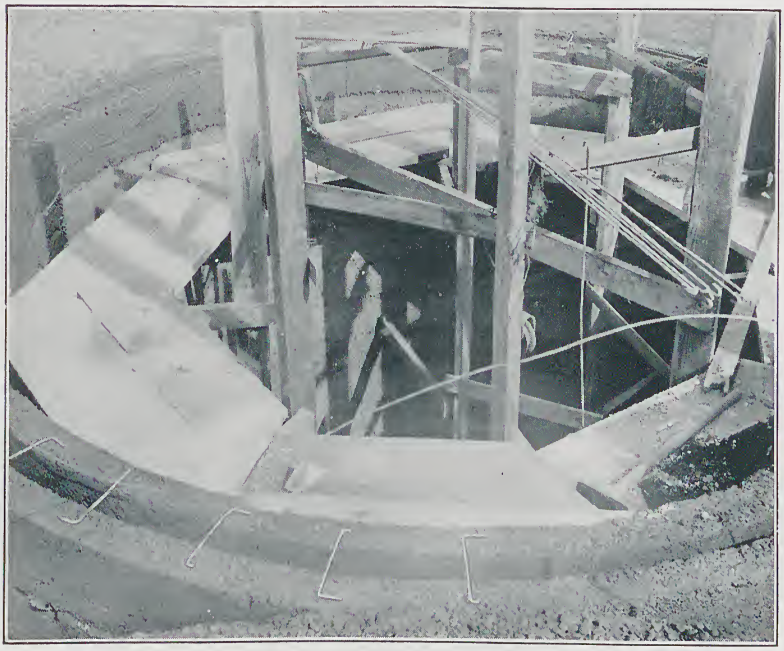
Accompanying sketches show details of reinforcement around doorways. These must be very carefully observed, otherwise doorway



Reinforcement for continuous doorway opening



Arrangement of reinforcement around intermittent doorway openings



A concrete silo under construction, showing forms and reinforcing rods

openings will weaken the structure. Tables on page 138 show quantity of reinforcement required, both rods and mesh, for silos of various inside diameter and height. There should be no variation from these recommendations.

Any one can understand that when a silo has been filled with silage the contents subject the walls to considerable pressure. This is greatest at the bottom, and is also greater than usual when considerable liquids are in the silage. As the pressure is increased toward the bottom, more reinforcement must be used in the lower portion of the structure than nearer the top. Vertical reinforcement also is needed in all monolithic silos. This usually consists of ⅜- or ½-inch steel rods spaced 30 inches apart along a line corresponding to the center of the silo wall. Either square twisted or round rods may be used. In using any one of the various kinds of metal fabric as a substitute for rods in reinforcing the silo, it is necessary to know that when making such substitution the correct amount of metal is used.

Hoops of horizontal reinforcement where rods are used should be wired to the vertical with 12- or 14-gauge iron wire so that all reinforcement will be firmly held in correct relative position during concreting. As steel rods come only in certain lengths, it will be necessary to use more than one piece for a stretch of vertical reinforcement as well as for one of the circles or hoops of horizontal reinforcement. In such cases the rods must be spliced by lapping. When ⅜-inch rods are used, the lap should be not less than 18 inches and for ½-inch rods 30 inches.

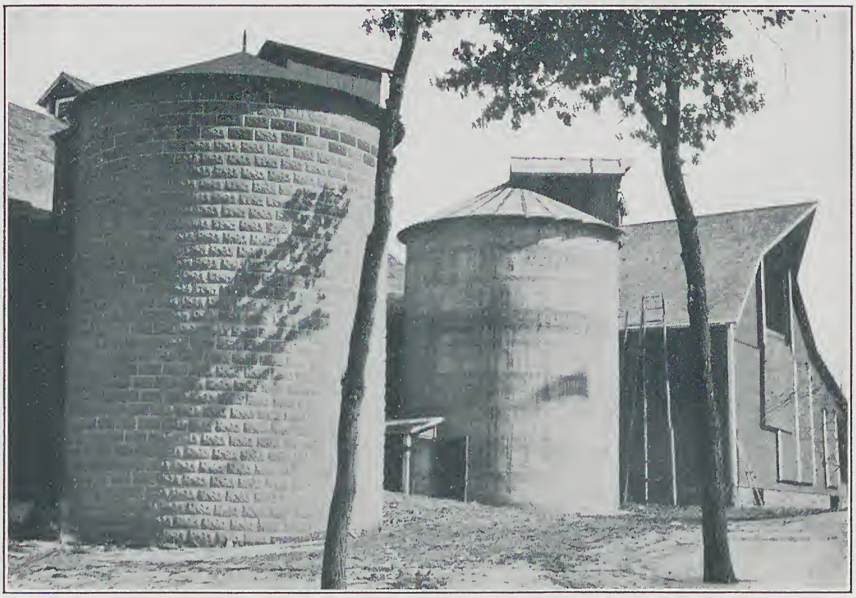
Reinforcing, as discussed on pages 168 to 172, should be carefully studied, as a knowledge of the fundamental principles for reinforcing will be of material assistance in planning the concrete silo.

Monolithic Construction

In building monolithic silos only one complete ring per day can be cast on the structure. Under favorable conditions this concrete will have hardened sufficiently during a period of twenty-four hours to permit raising forms an equal distance for the next day's concreting. This procedure is carried on until the structure is completed. In cold weather concrete does not harden rapidly, so the forms must not be raised at the end of twenty-four hours unless the concrete has hardened sufficiently to make such procedure safe. Freezing should not be mistaken for naturally hardened concrete.

The precautions necessary for concrete work in cold weather are outlined on pages 178 to 180, and before proceeding with the construction, these pages should be studied carefully.

Pages 172 and 173 contain useful information on the placing of concrete, and by adhering to



A pair of silos, block or monolithic, make a good team to pull your livestock business profitably through four seasons

these suggestions the concrete silo will not alone be serviceable, but its appearance will be improved.

Final appearance of a silo depends principally upon the care with which forms are set, plumbed, and raised, and the careful spading done when the concrete is placed in the forms. Not only should spading be done thoroughly between forms to eliminate aggregate pockets giving maximum density, but it should also be thoroughly worked around reinforcement so as to embed it and give a complete bond. Thorough spading will help materially to make the structure watertight and to produce smooth interior and exterior surfaces.

Surface Finish

While not necessary to do so, the exterior of the silo can be given a uniformly even appearance by applying a coat of cement and water paint after concreting has been completed. The same applies to the interior wall face, and such a wash will contribute to sealing pores or irregularities in the surface.

Fireproofness is not secured in the fullest measure unless the structure is finished with a concrete roof. See tables on pages 106 and 107, and detailed drawing on page 139.

Considerable space has been devoted to the description of the monolithic silo because many details of its construction apply to block and concrete stave silos. Foundation requirements for all three types are the same, and other features, such as doorway openings, chutes, proper location of structure, etc., apply to all types.

Block Silos

Block silos, as the name implies, are built of concrete block similar to those used in other concrete block construction, except that the block are molded in special machines to give them a form corresponding to part of the circumference of a circle. When laid in courses, they thus produce a circular structure of the height and diameter desired.

Details of block making, given on pages 77 and 78, apply to the making of silo block. Such block can be home made if the intending builder cares to go to the expense of securing one of the machines used for the purpose. If not, the block may be purchased from a products plant. Some little skill is required to make concrete block, and this is not likely to be possessed by the novice or casual worker. Proper curing of the block is best accomplished in steam curing chambers which the home worker in concrete cannot provide.

The average home builder is unskilled at masonry work. The laying up of a concrete block silo is essentially a masonry job, and it involves, among other things, well-bedded mortar joints in order that the finished structure

Distance from top of silo	Diameter of silo (inside)					
	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
Feet	1	1	1	1	1	1
	0	0	0	0	0	0
2	1	1	1	1	1	1
	0	0	0	0	0	0
	1	1	1	1	1	1
4	0	0	0	0	0	0
	1	1	1	1	1	1
	0	0	0	0	0	0
6	1	1	1	1	1	1
	0	0	0	0	1	1
	1	1	1	1	1	1
8	0	0	0	1	1	1
	1	1	1	1	1	1
	0	0	1	1	1	1
10	1	1	1	1	1	1
	0	1	1	1	1	1
	1	1	1	1	1	1
12	0	1	1	1	1	1
	1	1	1	1	1	2
	1	1	1	1	2	1
14	1	1	1	1	1	2
	1	1	1	2	2	1
	1	1	1	1	1	2
16	1	1	1	2	2	1
	1	1	2	1	1	2
	1	1	1	2	2	1
18	1	1	2	1	1	2
	1	1	1	2	2	2
	1	1	2	1	1	2
20	1	1	1	2	2	2
	1	2	2	1	2	2
	1	1	1	2	2	2
22	1	2	2	2	2	2
	1	1	1	2	2	2
	1	2	2	2	2	2
24	1	1	1	2	2	2
	1	2	2	2	2	1
	2	1	2	2	2	1
26	1	2	2	2	2	1
	2	1	2	2	1	2
	1	2	2	2	1	1
28	2	1	2	2	1	1
	1	2	2	2	1	2
	2	1	2	2	2	1
30	1	2	2	2	1	1
	2	2	2	1	1	2
	1	2	2	1	2	1
32	2	2	2	1	1	1
	1	2	2	2	1	2
	2	2	2	1	2	1
34	1	2	2	1	1	1
	2	2	1	2	1	2
	1	2	1	1	2	1
36	2	2	1	1	1	2
	2	2	2	2	1	1
	2	2	1	1	2	2
38	2	2	1	1	1	2
	2	2	2	2	2	1
	2	2	1	1	1	2
40	2	2	1	1	2	2

Mortar joints 8 inches apart.

No. 3 wires above this line.

$\frac{3}{8}$ inch round rods below this line.

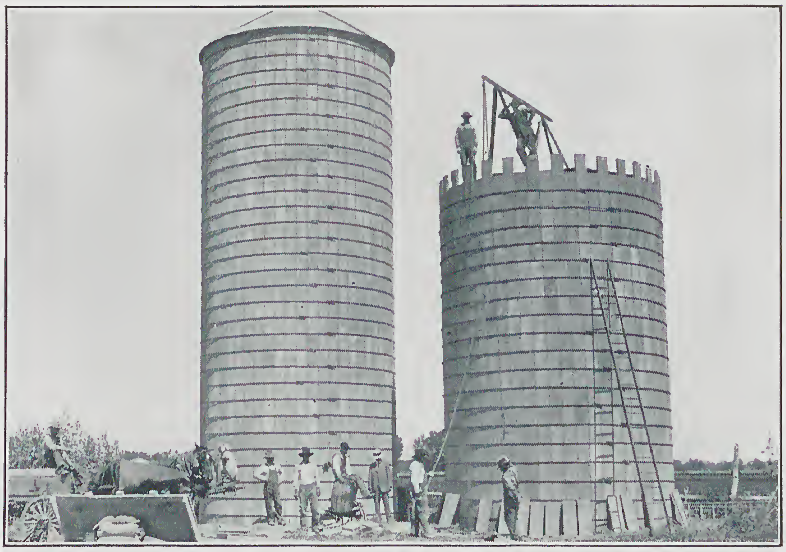
Chart showing reinforcing required at each joint of concrete block silos

shall have the required watertightness and leakproof qualities necessary. It is better to engage a local contractor to do the work.

Reinforcement of Block Silos

Block silos must be reinforced. Horizontal hoops in the form of round rods are embedded partly in the mortar joints and partly in grooves cast when the block is made. Usually a ¼-inch rod or No. 3 wire is used as reinforcement. A chart table on this page shows the quantity of this reinforcement that is necessary for the various dimensions of block silos.

Intermittent doors with concrete doorframes are generally preferred for block silos. The interior of the block silo may be given a coat of cement grout, like that used on the monolithic silo, and the roof and chute may be built in about the same manner, except that the chute is of concrete block, while the roof is of monolithic construction.



A concrete stave silo, like the block and monolithic structures, is windproof, rotproof, and fireproof

The details of the forms necessary for the construction of a roof for either a block or a monolithic silo are found on page 139.

Stave Silos

Both monolithic and concrete block silos meet all requirements of the ideal silo, but these requirements are also met by the concrete stave silo, which has for a number of years been increasing rapidly in popular favor, due largely to the expansion of the concrete products industry and the ease with which the concrete staves may be obtained in practically any part of the country from one of these products plants.

The concrete stave is a slab of concrete, generally from 2½ to 3 inches thick, 10 to 12 inches wide, and from 28 to 30 inches long, the variation in the foregoing dimensions meaning that the many types of concrete staves vary slightly in main dimensions. When used to lay up the wall, the staves are set on end and their edges interlock in different ways, depending upon the particular type of stave. In the main, differences are slight and of no importance because all types of concrete staves produce a first-class silo.

An advantage of the concrete stave silo which has been responsible for its rapid increase in popularity in the last two or more years is the fact that it can be very quickly erected. Speed of construction is necessarily limited on monolithic silos because forms can be raised only once in twenty-four hours. An average sized concrete stave silo is usually completed in three days.

There are a variety of staves used in concrete stave silo construction which enable the person who prefers this type of silo to have some range of choice as to type of stave or other detail. With concrete staves there is an unlimited latitude as to diameter and height of finished silo. Enclosure walls, troughs, corncribs and other barnyard equipment are also built of concrete staves.

Reinforcement of Stave Silos

The concrete stave silo, like the block and monolithic structures, is windproof, rotproof, and fireproof, and possesses a degree of permanence found only in concrete construction. The principal difference between concrete stave silos and the other types of concrete silos lies in the manner in which reinforcement is applied. In the monolithic and block silos reinforcement is embedded in the concrete. In the concrete stave silo it takes the form of hoops placed at suitable intervals on the outside and tightened by means of turnbuckles.

Concrete stave silos are sometimes equipped with chutes built of the same kind of staves. Usually they have a galvanized metal roof.

As in the case of monolithic and block silos, it is not recommended that the inexperienced man erect his own concrete stave silo, but rather engage a contractor to do it for him.

A feature of many circular concrete barns is to have the silo in the center

Concrete Barns

CONSIDERABLE choice may be exercised in the floor plan arrangement of a barn. Stock may face in or face out—either arrangement is practical.

If the structure is a general purpose barn in which the lower floor is used to house horses and other live stock, as well as dairy cattle, the dairy stock quarters must be completely separated from those of the other animals so that no objectionable odors will contaminate the milk. Windows in a dairy barn should be screened to keep out flies. Foundation and wall requirements for barns have been outlined on pages 57 to 62. No two farmers' barn requirements are the same, so standard plans are impracticable.

Both dairy and general purpose barns of the circular type have been increasing in popularity of late years. There are many examples of such structures throughout the country, a large number of which have been built of concrete block. A feature of many circular barns is to have the concrete silo in the center. This is ideal with respect to ease of feeding. Silos are illustrated on pages 42 to 45 and pages 136 to 144.

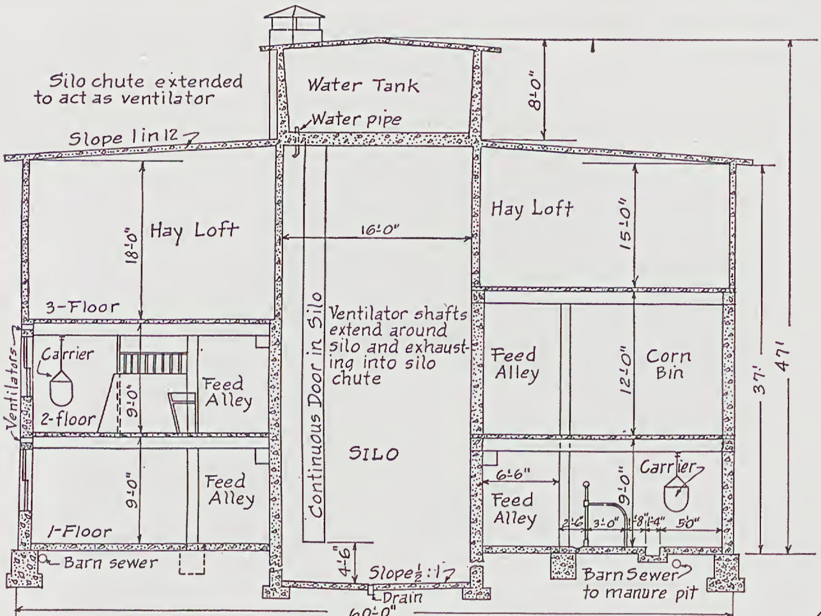
Length of cow-stalls usually depends upon the breed of stock. Guernseys and Jerseys are comfortably provided for in stalls four and a half feet long. Holsteins and large breeds require stalls at least five feet long. A drawing on page 67 shows vertical cross-section of a standard dairy barn floor, which includes feeding passageway, manger, stall, cleaning gutter, and driveway. This sketch represents half of the section through a barn in which the cattle face out.

Floors should have a slope about one inch between the foot and head of the cattle, so that all liquids will flow into the manure gutter and so that the floor can be quickly flushed and drained.

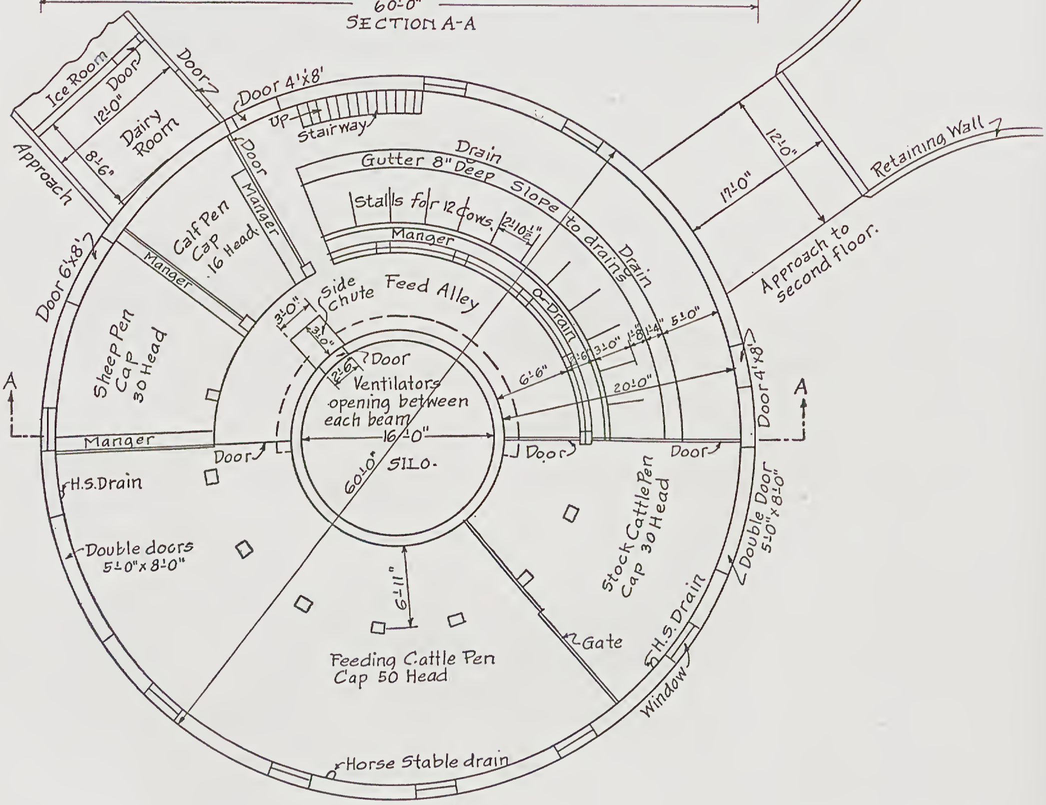
Gutters are made from 16 to 18 inches wide, so they can readily be cleaned with an ordinary shovel. Gutters should slope 1/16 inch per foot for drainage, and are usually connected with a tile line so that all liquids may drain into a concrete manure pit. Concrete manure pits with designs and drawings are shown on pages 74 and 75.

Concrete mangers are usually made continuous, with a drain at one end for cleaning and flushing. Feed alleys should be built wide enough to make feeding operations easy and convenient.

Details of construction for placing of concrete with respect to installation are available from manufacturers of standard dairy barn equipment.



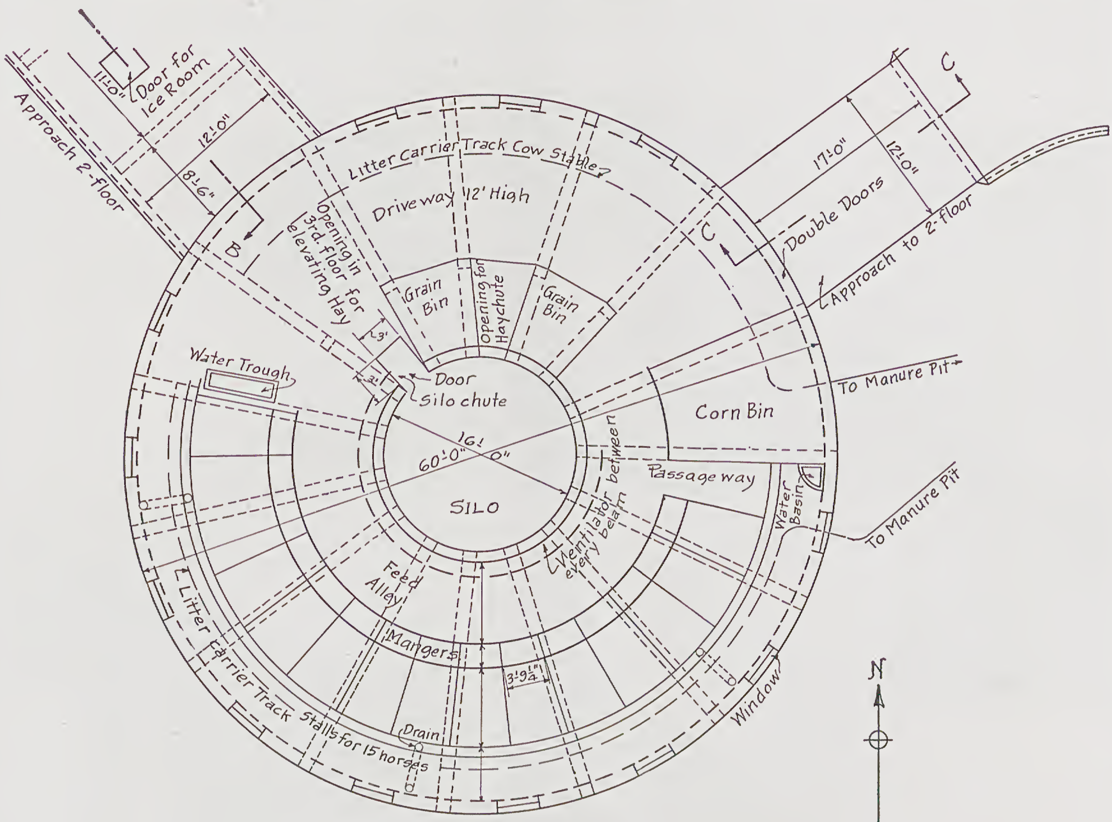
SECTION A-A



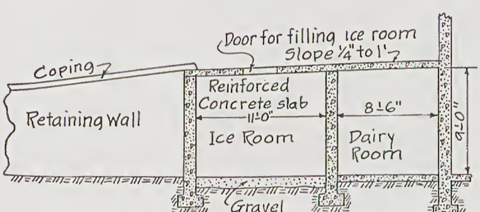
PLAN FIRST FLOOR

Barns built entirely of concrete are quite common in many parts of the country. Both monolithic and block type of construction are practical.

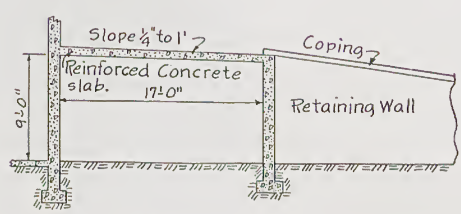
Where the investment for an all-concrete barn is prohibitive, many farmers have built the footings, walls, and the first floors of concrete, replacing from time to time the different units of the wooden superstructure until they have attained the complete building of concrete, requiring no replacement and the minimum of maintenance. For absolute protection the roof as well as the walls and floors should be of fire-resistive materials.



PLAN OF SECOND & THIRD FLOORS



SECTION B-B

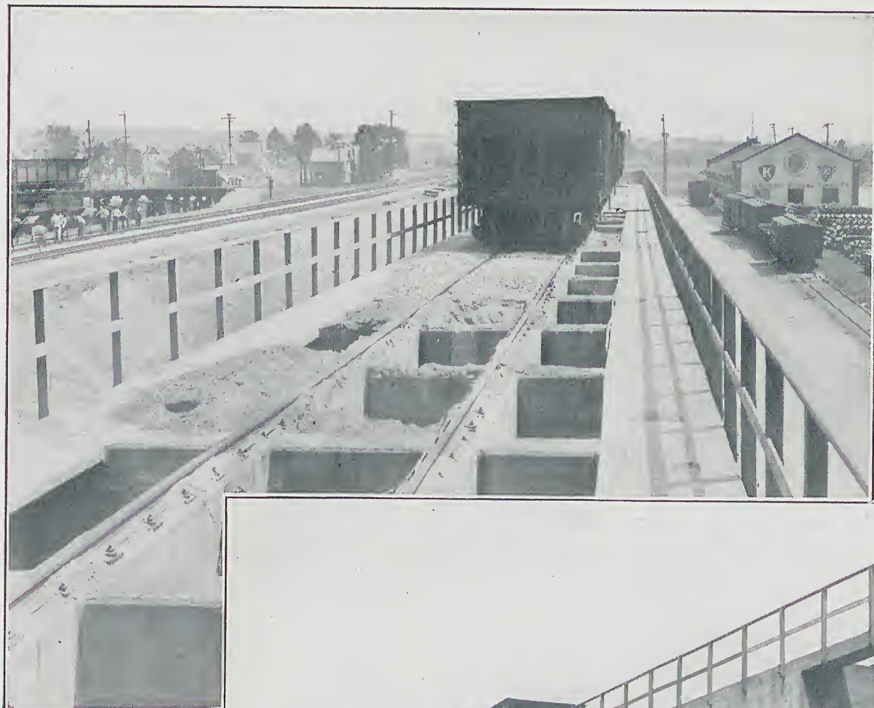


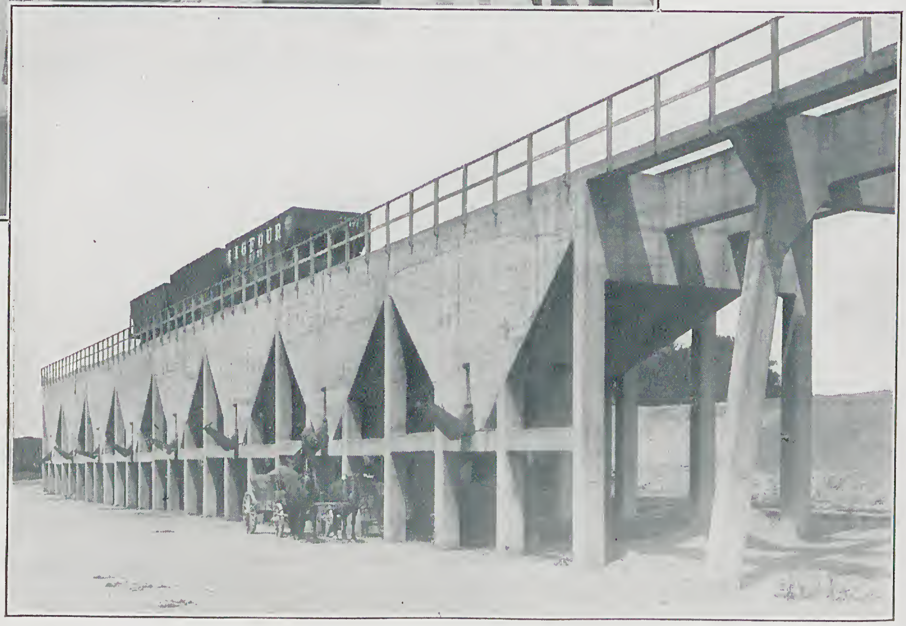
SECTION C-C

The designs shown of a monolithic concrete barn actually built by a farm-owner and his labor in central Illinois. All of the work was done during spare hours, and for that reason construction of the barn extended over a period of three years. The actual enclosure walls, however, were quickly completed and a portion of the barn made available for use, while the remainder was finished at leisure. This barn shows a feature common to the most successful circular barns in that the silo is at the center of the structure, thus making feeding of stock convenient. Notice that a water tank is built on top of the silo. No design details of reinforcing are shown. These have to be calculated for every structure of this kind, depending upon its size

REFERENCES FOR CONSTRUCTION

	PAGES		PAGES
Foundations and walls	9, 57 to 62	Dairy houses	38, 108 to 111
Walks	10, 64 to 68	Watering troughs	41, 93 to 96
Steps	12, 13, 69	Silos	42 to 45, 136 to 144
Illustrations of barns	27 to 31	Building out rats	63
Barn approaches	32, 70	Barn riser	71
Manure pits	32, 33, 74, 75	Roofs	106, 107
Concrete in the barn	34, 35	Part Three	153 to 185





A modern coal pocket

Coal and Material Bins

BECAUSE of the permanence of concrete for the mechanical handling of coal, sand, crushed stone, and other materials stored in bins or "pockets," concrete bins have largely replaced other types. Spread out in the usual fashion, a retail material dealer's yard occupies much valuable ground space. "Building the yard up in the air," so to speak, by using concrete pockets, less yard space is necessary and at the same time added profits to the business result through elimination of much hand labor.

A modern concrete pocket is equipped with machinery that does the work of handling at a fraction of time and expense involved with old methods. In addition it provides fullest protection against fire and depreciation.

One of the popular forms of material bins is circular, which is practically a counterpart of the monolithic, concrete block, or concrete stave silo—for coal pockets and material storage bins are built by using concrete in all three of the forms mentioned. Each pocket must be designed in accordance with the capacity to be provided. The general construction requirements for circular structures of this kind are the same as those governing the construction of concrete silos on pages 136 to 144.

Tables on the following page show capacities of pockets of various dimensions.

CAPACITIES OF CIRCULAR POCKETS IN TONS OF BITUMINOUS COAL*

Height of Coal Pocket	Inside Diameter of Coal Pocket			
	12 Feet	14 Feet	16 Feet	18 Feet
30 feet	85	115	151	191
40 feet	113	154	201	255
50 feet	141	192	251	318
60 feet	170	231	302	382

* For anthracite coal add 10 per cent to above capacities.

Concrete pockets can be reinforced either with round or square bars. Accompanying tables show reinforcement required and examples of use for circular bins for both round rods and square bars. These tables are figured for structures ranging in diameter from 12 feet to 18 feet by variations in diameter of 2 feet in each instance.

TABLE SHOWING HORIZONTAL STEEL REINFORCING IN CIRCULAR BINS

This Table is for Round Rods

Distance from Top in Feet	12 Ft. Diam.	14 Ft. Diam.	16 Ft. Diam.	18 Ft. Diam.
0–10	3/8″–12″ ctrs.	3/8″–12″ ctrs.	3/8″–10″ ctrs.	3/8″–8″ ctrs.
10–20	3/8″– 8″ "	3/8″– 8″ "	3/8″– 8″ "	3/8″–6″ "
20–30	3/8″– 8″ "	3/8″– 8″ "	3/8″– 6″ "	3/8″–6″ "
30–40	3/8″– 8″ "	3/8″– 8″ "	3/8″– 6″ "	3/8″–6″ "
40–50	3/8″– 6″ "	3/8″– 6″ "	3/8″– 6″ "	3/8″–6″ "
50–60	3/8″– 6″ "	3/8″– 6″ "	1/2″– 8″ "	1/2″–8″ "
60–70	3/8″– 6″ "	3/8″– 6″ "	1/2″– 8″ "	1/2″–8″ "
70–80	3/8″– 6″ "	3/8″– 6″ "	1/2″– 8″ "	1/2″–8″ "

Note.—3/8″–6″ ctrs. indicates that 3/8″ round rods are spaced 6″ center to center between the ten-foot sections as indicated.

Note.—Vertical reinforcement 1/2″–24″ ctrs. or 3/8″–12″ ctrs., regardless of size of bin.

Problem.—Let it be assumed that it is desired to determine the size and reinforcing for a coal pocket of the silo type having a capacity of 200 tons. From table of capacities we note a silo 16 ft. in diameter and 40 ft. high will be required. From above table of reinforcing a silo 40 ft. high and 16 ft. in diameter requires horizontal reinforcing as follows: 3/8″ round rods 10″ ctrs. in top 10 ft.; 3/8″ round rods 8″ ctrs. in second 10 ft.; 3/8″ round rods 6″ ctrs. in lower 20 ft.

For vertical reinforcing 3/8″ round rods 12″ ctrs. will be required.

TABLE SHOWING HORIZONTAL STEEL REINFORCING IN CIRCULAR BINS

This Table is for Square Bars

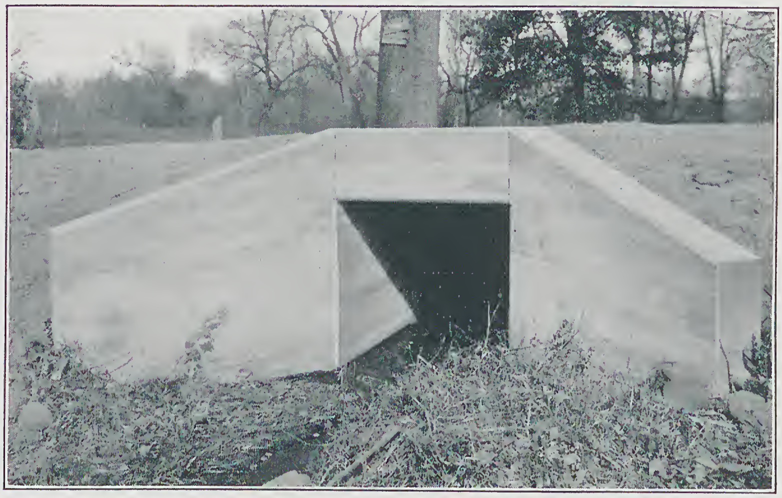
Distance from Top in Feet	12 Ft. Diam.	14 Ft. Diam.	16 Ft. Diam.	18 Ft. Diam.
0–10	3/8″–16″ ctrs.	3/8″–16″ ctrs.	3/8″–13″ ctrs.	3/8″–10″ ctrs.
10–20	3/8″–10″ "	3/8″–10″ "	3/8″–10″ "	3/8″– 8″ "
20–30	3/8″–10″ "	3/8″–10″ "	3/8″– 8″ "	3/8″– 8″ "
30–40	3/8″–10″ "	3/8″–10″ "	3/8″– 8″ "	3/8″– 8″ "
40–50	3/8″– 8″ "	3/8″– 8″ "	3/8″– 8″ "	3/8″– 8″ "
50–60	3/8″– 8″ "	3/8″– 8″ "	1/2″–10″ "	1/2″–10″ "
60–70	3/8″– 8″ "	3/8″– 8″ "	1/2″–10″ "	1/2″–10″ "
70–80	3/8″– 8″ "	3/8″– 8″ "	1/2″–10″ "	1/2″–10″ "

Note.—3/8″–10″ ctrs. indicates 3/8″ square bars spaced 10″ center to center between the 10-foot sections as indicated.

Note.—Vertical reinforcement 1/2″ square bars–24″ ctrs. or 3/8″ square bars–16″ ctrs., regardless of size of bin.

Problem.—Let it be assumed that it is desired to determine the size and reinforcing for a coal pocket of the silo type having a capacity of 200 tons. The table of capacities shows that a silo 16 ft. in diameter and 40 ft. high will be required. From above table of reinforcing a silo 40 ft. high and 16 ft. diameter requires horizontal reinforcing as follows: 3/8″ square bars 13″ ctrs. in top 10 ft.; 3/8″ square bars 10″ ctrs. in second 10 ft.; 3/8″ square bars 8″ ctrs. in lower 20 ft.

For vertical reinforcing 3/8″ square bars 16″ ctrs. will be required.



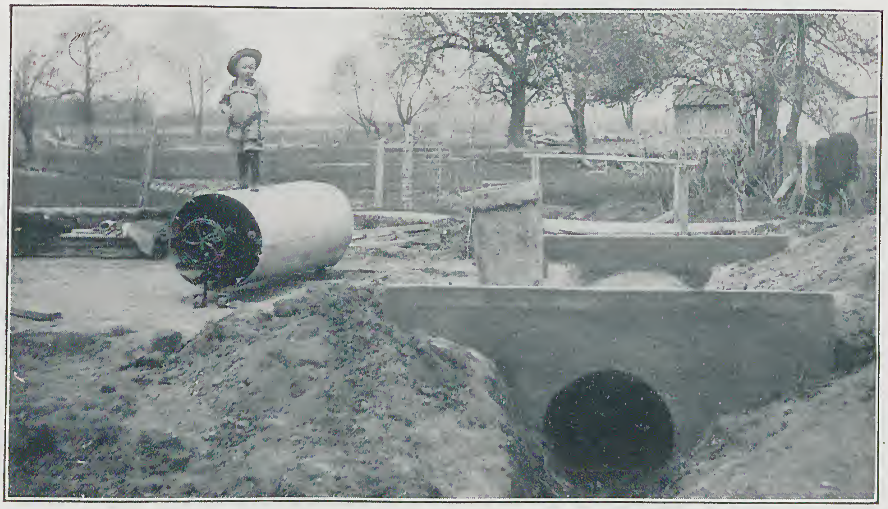
A serviceable, inexpensive box culvert

Culverts and Bridges

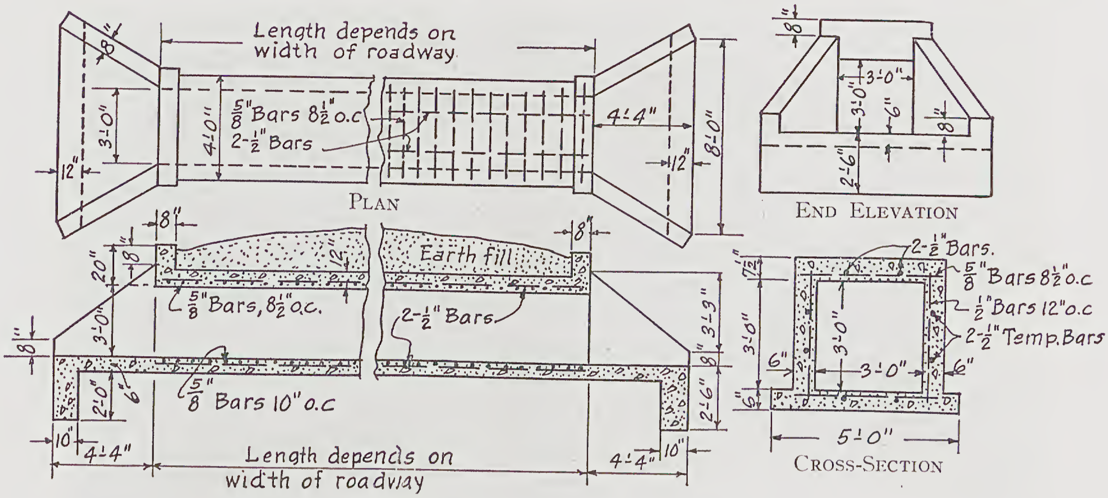
THE simplest form of concrete culvert is one made of precast concrete pipe, similar to large drain tile or sewer pipe. Pipe is adapted to culvert construction in all sizes of openings from twelve inches upward to the largest size of pipe made, providing the largest size will otherwise suit requirements of the location. Good practice limits the minimum size of waterway openings to twelve inches, because smaller openings are too easily closed with débris and in that way rendered ineffective unless constant attention is given to keep them open.

The box culvert is more generally used than other types except precast pipe, because very simple forms are required and the concrete work is easily done. A box culvert is merely a long box with concrete top, sides, and bottom—in effect, a small concrete bridge with top slab acting as the floor to support the load of traffic. The slab must be reinforced with steel rods or heavy mesh fabric. A floor should be laid at the bottom of box culverts in order to prevent wash and scour of streams from undermining the sides and causing the culvert to settle and probably break.

The arch culvert is different from the box culvert in that its top is in the form of an arch instead of flat slab. Small arch culverts do not require reinforcement, but large arches are sometimes designed for reinforcement in order to economize in the use of concrete. Forms



Commercial forms for building culverts. These forms are collapsible, making them easy to remove



Concrete box culvert with wing walls. The following calculations show how computations were made in order to determine total quantity of materials required on the basis of each foot of roadway width. Total reinforcement in the computations is on the basis of 20 feet length of culvert

HIGHWAY CULVERT
1 : 2 : 4 Mix

BOX

Bottom	= .5 × 1 × 5	= 2.5 cu. ft.
Sides	= .5 × 1 × 3 × 2	= 3.0 cu. ft.
Top	= .6 × 1 × 4	= 2.4 cu. ft.
		7.9 cu. ft. or .29 cu. yd. per foot width of road

WINGS

Base	= 5.00 × 5.5 × 4.33 × 2	= 23.8 cu. ft.
Footing	= .83 × 2.0 × 9.00 × 2	= 29.9 cu. ft.
Wing walls	= .66 × 2.4 × 2.16 × 4	= 13.6 cu. ft.
		67.3 cu. ft.
Parapet walls = 4 cu. ft.		4.0
		71.3 cu. ft.
		2.6 cu. yds.

Material Required

BOX

Per foot width of roadway (as needed)

Lehigh cement	= .44 bbl.
Sand	= .13 cu. yd.
Pebbles	= .26 cu. yd.

WING ENDS (2)

Lehigh cement	= 3.9 bbls.
Sand	= 1.2 cu. yds.
Pebbles	= 2.4 cu. yds.

Reinforcement

Assume Twenty-foot Roadway as example

TOP OF BOX

Transverse bars 8½" o.c.

29 ⅝" □ bars × 3' 10" = 112 feet

Longitudinal bars

2 ½" □ bars × 19' 10" = 40 feet

BOTTOM OF BOX

Transverse bars @ 10" o.c.

25 ⅝" □ bars × 4' 0" = 100 feet

Longitudinal bars

2 ½" □ bars × 19' 10" = 40 feet

SIDES OF BOX

Vertical bars

21 ½" □ bars × 3' 6" = 74 feet
148 feet for both sides

Horizontal bars

2 ½" □ bars × 19' 10" = 40 feet
80 feet for both sides

SUMMARY OF STEEL

⅝" □ bars 212 feet @ 1.33 = 282 lbs.
½" □ bars 308 feet @ .85 = 262 lbs.
Total = 544 lbs. of reinforcement steel

for arches are more difficult to build, and more expensive than for simple box culverts.

When installing concrete pipe culverts, the pipe is laid in a carefully prepared trench properly curved at the bottom, so that everywhere the pipe will have a uniform support as bedded. The manufacture of concrete pipe has been discussed on pages 76 to 83, to which the reader is referred for other details.

The side walls of small box and arch culverts in firm soil usually provide sufficient foundation bearing. In soft or doubtful soils a spread footing should be placed under the side walls. All flat slab or box culverts, regardless of size, should be reinforced. Usually such reinforcing is placed with its center point about 1½ inches from the bottom of the top slab, and in the case of the floor slab, 1½ inches from its top, because the floor slab receives pressure from beneath acting upward.

Wing walls on bridges and culverts hold back the road fill and prevent the stream from washing a channel through the road fill. Wing walls used with concrete pipe culverts are generally built straight and parallel with the road. End and wing walls for box or arch culverts are either straight and parallel with the road, or flared at an angle to it. The flared type is more effective in confining the road fill. Especially should these be used on the

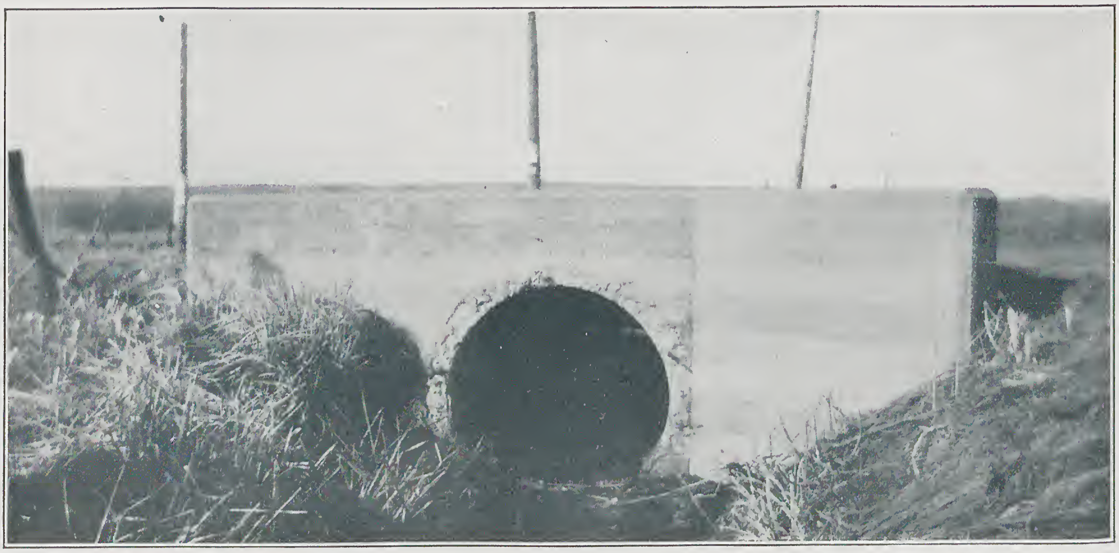
Method of placing reinforcing in small culvert or bridge, showing lateral and longitudinal reinforcing

up-stream end of the culvert. Frequently end and wing walls are reinforced in order to economize on concrete.

Road covering over all culverts should be at least two feet unless the road surface is concrete pavement. If less than two feet of earth is used as a covering for a culvert where the highway material is merely earth, gravel, or macadam, there is danger that the impact of traffic will not be sufficiently cushioned to prevent damage to the culvert. Instead of letting the concrete highway pavement serve as the top, the culvert should be low enough so that, in addition to its own top slab, the additional thickness of the concrete road slab will be laid on top of it. In such case the top slab of the culvert should be painted with something like asphalt to allow free movement of the road slab, due to volume changes under different temperature conditions.

Concrete culverts should be made the full width of the road, including shoulders.

Most of the remarks just made about concrete culverts apply to concrete bridges. A bridge implies a larger structure, although no definite line is drawn that would indicate where the structure changes from the classification of culvert to that of bridge. In building a bridge the services of an engineer or a contractor will be required.



Concrete pipe culvert with wing walls

THE FUNDAMENTAL PRINCIPLES *of* CONCRETE

THE adaptability of concrete is due to its being plastic in its first stage of use. Immediately after mixing it is a wet mass that can be placed in forms or molds, where it will harden in any shape or form intended. The result is in reality a manufactured stone, and depending upon how the ingredients of concrete are selected, mixed, and manipulated, almost any variety of natural stone can be equaled or surpassed. As used in building construction, concrete is superior to natural stone because it is always under control.

Concrete is a product resulting from proper mixture of cement, sand, stone, and water.

Concrete may be used for either monolithic or unit construction.

Simple fundamentals must be observed in doing any kind of concrete work and they are of utmost importance. Neglect of any one or several of them, in spite of their seeming insignificance, may be the underlying cause of failure or dissatisfaction.

Lehigh portland cement is a scientifically prepared commodity which hardens upon the addition of water. In concrete, cement acts as a mineral glue, binding firmly together the sand, gravel, and stone used in the mixture.

Selection of Materials

The materials that enter into a concrete mixture must be selected with great care.

The selection of Lehigh cement insures a standardized, dependable product.

Sand, gravel, and stone are quite variable. Sand is frequently dirty, due to the presence of one or more foreign materials, such as silt or organic matter. Rotted vegetable material may be present in such a fine form as to be difficult to detect; or considerable clay may be in the sand. The sand may be too fine instead of uniformly well graded from the coarser to the finer particles.

Practically the same impurities may be found in gravels or crushed stone, particularly in gravels. The pebbles may be coated with clay or other firmly adherent foreign material which will prevent the cement from performing its intended function of binding the concrete firmly together as a mass.

Broken stone that is prepared particularly for use in concrete is not likely to have so many objectionable features as may be found in natural gravel. It may contain an excess of dust, which is objectionable for the same reasons that foreign material is objectionable in sand and gravel, that is, the dust prevents the cement from performing its bonding properties.

Therefore, one of the fundamentals governing the selection of materials to be used in a concrete mixture is that *these materials shall be clean.*

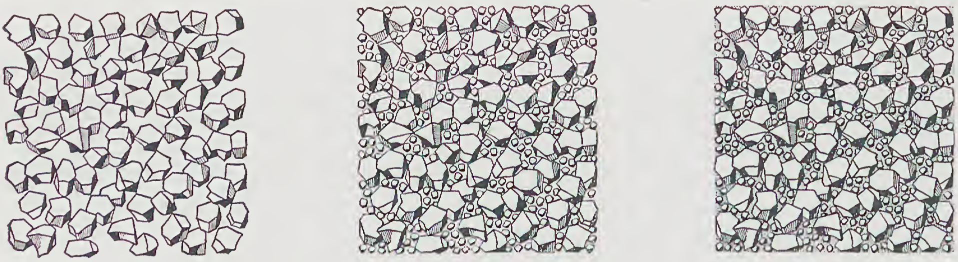
Definition of Aggregates

The sand and pebbles or crushed stone used in making concrete are commonly referred to as aggregates. Sand, or material used in place of sand, such as stone screenings, is referred to as fine aggregate, while pebbles, usually and improperly referred to as gravel, and crushed stone are known as coarse aggregates.

Coarse aggregates may be pebbles obtained from screening bank-run gravel or may be obtained by crushing natural rock to a suitable size, or from crushed slag or hard cinders.

An arbitrary line is drawn to distinguish between fine aggregate and coarse aggregate. All material that will pass a sieve having ¼-inch meshes is known as sand or fine aggregate. All material which will not pass such a screen and ranges in size up to the largest permissible particles usable in ordinary concrete mixtures, is called coarse aggregate. In the average run of concrete work coarse aggregate used seldom exceeds 1½ or 1¼ inches in greatest dimension, and ranges from that size downward to practically ¼ inch.

Both sand and coarse aggregate should consist of volumes in which the particles are well graded from coarse to fine. An excess of either coarse or fine particles or any considerable deficiency in range of grading makes the material uneconomical because of the added



Illustrating the voids in aggregates

quantity of cement required to fill voids or air spaces in the bulk.

The following example is illustrated by the drawings at the top of this page.

Suppose we have a box of exactly one cubic foot capacity when level full. We start to fill this box first by putting into it as many pieces of crushed stone or pebbles as it will contain, say, uniformly 1½ inches in greatest dimension. No matter how carefully this volume of material, which in bulk measures one cubic foot, is shaken or settled into place in the box there will still be a large volume of unfilled space in our cubic foot of bulk because the particles uniformly 1½ inches in size will not fit together so closely as to make literally a solid mass. We can begin to take up some of this space by adding a certain volume of smaller pebbles or pieces of crushed stone, say ½ or ¾ inch in diameter. By mixing these thoroughly with the one cubic foot of the larger particles we will find that these combined volumes of coarse and finer particles will still all go into our cubic foot box—and there are still unfilled spaces between particles in the box. Then we can take some sand graded from ¼ inch down to fine particles and can mix a considerable volume of this with the material already in the box and again the box will hold all of this mixture. Still there are unfilled spaces; and it will be found that a considerable volume of cement can be added to the three lots of material we have already placed in the box and the box will hold all of such mixture.

Mixtures Should Be Graded

This should clearly illustrate the principle and necessity of grading mixtures to produce a dense mass, for a large portion of the strength of concrete depends upon its density, that is, the absence of air spaces or unfilled spaces commonly called voids. It is essentially on the principle just illustrated that concrete is proportioned, bearing in mind that the mixture which we have just been discussing still lacks the water necessary to finish the operation and make a concrete mixture.

Other fundamental requirements govern the quality of concrete. In addition to having clean materials well graded, the sand and pebbles or broken stone used should possess hardness.

In many cases they should be chosen with regard particularly for their fire-resistive qualities as individual materials.

Fire-Resistive Aggregates

Lehigh cement in the process of manufacture is exposed to very high heat, and therefore is inherently highly fire resistive.

Some stones and rocks found in nature are of volcanic origin. Traprock is an example. Aggregate obtained by crushing these volcanic rocks is particularly valuable for concrete mixtures intended for use in building construction that has to be highly fire resistive. It is because blast furnace slag has also been exposed to high heat that slag aggregate is used where high fire resistance of concrete is desired or necessary.

When considering materials to be used in concrete, hardness and toughness have different meanings. A hard material may be brittle. It may be tough as well as hard, and is therefore not particularly brittle. Toughness is a quality very much desired in concrete aggregates used in such construction as roads, streets, or other pavements that are to be subjected to traffic abrasion and impact.

There is a great variety of natural rock that can be crushed and used as concrete aggregate. Various natural rocks have different degrees of hardness, toughness, and fire resistance, and the physical properties of the aggregate being used should be known in order to be

sure that it is best adapted to the concrete in which it enters. Granite, while hard and quite tough, is not the best aggregate for high fire resistance. Traprock and slag have this important quality. Sandstone, and other natural rocks like it, should not be used where toughness and great strength are required, although it is suitable for many classes of concrete work.

A small quantity of organic impurity in aggregates makes them unfit for use unless such foreign material is removed. This usually is done by washing. It is, therefore, important to test sand to see whether such foreign material is present. The coating of vegetable matter on sand grains may not only prevent the cement from hardening and keep it from performing its bonding function, but may affect it chemically. Frequently the quantity of foreign material present is so small that it cannot be detected by the eye, yet may prevent the concrete from ever reaching any appreciable strength.

The Colorimetric Sand Test

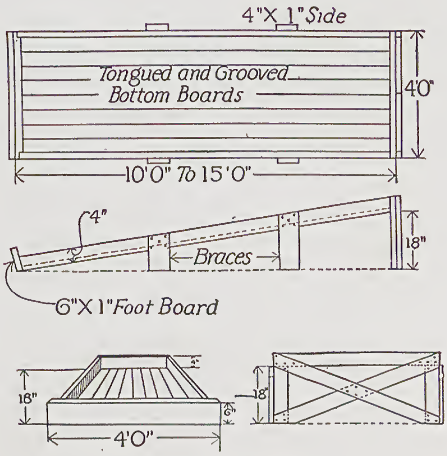
The following is a simple test to determine the presence of an objectionable quantity of organic matter in sand. This is known as the colorimetric test, and was developed by the Structural Materials Research Laboratory of Chicago:

Obtain a 12-ounce graduated bottle and fill to the 4½-ounce mark with the sand to be tested. Add to this a 3 per cent. solution of caustic soda, until the combined volume of sand and solution after shaking amounts to 7 ounces.

Let this stand for twenty-four hours. At the end of this time observe the color of the liquid above the sand. If the solution is colorless or nearly so,—that is, has but a pale yellowish color,—the sand may be considered sufficiently free from organic impurities for any use. A brownish yellow solution, or one darker than a pale straw, indicates a sand which should not be used in important concrete work, such as that required in roads and pavements or in reinforced concrete building construction. If, in general, the color is brownish throughout, the sand should not be used in anything but unimportant work, such as footings or foundations that are not to carry heavy loads. A dark brown solution shows a sand which should not be used and should be rejected.

This test furnishes a simple and inexpensive method of detecting the presence of such organic impurities as humus. The test is used by a large number of laboratories, engineers, and contractors in passing on the suitability of sand for use in concrete.

If this test proves the sand objectionable, then it must either be discarded or in some way washed to remove the foreign material.



Washing platform

Simple devices for washing can easily be made. One of these consists of a wooden trough or sluiceway elevated at one end at such an angle with the horizontal that the materials to be washed will, when thrown in at the upper end of the trough and forced down through its length, be so agitated or tossed about by running water, kept playing in the upper end of the trough, as to free the particles from objectionable material. Pebbles and screenings from crushed stone can be washed in a similar manner.

The reader has probably observed that several times the word "pebbles" has been used in speaking of coarse aggregate. This makes it necessary to call attention to the bad practice often followed by many concrete workers in taking the natural run of material as it comes from a gravel bank and using it with cement and water for a concrete mixture. The objection to this is that no gravel bank runs uniform with respect to the contained volumes of sand and coarse aggregate as already defined. Practically every gravel bank contains more sand than coarse aggregate, usually

twice as much, and if the unscreened material is used, the amount of cement required with a given volume of such material would be considerably in excess of an economical quantity to produce required strength if screened and graded materials had been used. It is, therefore, profitable as well as necessary to screen bank-run gravel into two volumes, so that the sand which passes through the ¼-inch mesh screen can be properly reproportioned with the coarser particles or pebbles.

Since many gravel banks contain a considerable volume of pebbles in excess of 1½ inches in diameter, it may be necessary to again screen the mass rejected by the ¼-inch screen so that the coarse aggregate will have the grading required.

In laboratory experiments concrete mixtures are usually made with every consideration for the refinements of proportioning and mixing just detailed. In the field, however, these requirements are not always practicable, so they are approached as nearly as possible by careful observance of the fundamentals already given and by sufficient experimenting to determine an arbitrary mixture for various classes of work, such mixtures being then adhered to throughout particular pieces of construction or portions thereof.

Sizes of Aggregates

With proper selection in grading of materials and correct proportions of all ingredients we can approach an ideal mixture even in general practice, but to do this some other fundamentals in addition to those already mentioned must be observed.

An excess of very fine particles in the sand is to be avoided although it is necessary that considerable fine material be present in order to reduce voids. Any quantity greatly in excess over that required for this purpose has a tendency to diminish the strength of the concrete.

Within reasonable limits the strength of the concrete increases with the size of the aggregates. In thin reinforced sections, in fact, in the general run of concrete work, the maximum size of coarse aggregate should not exceed 1¼ inches. Sometimes the maximum limit is one inch because of the nature of the work. In mass concrete, such as heavy foundations and very thick walls or thick floors without reinforcement, the size of coarse aggregate may often range up to 2½ or 3 inches.

The shape of aggregate particles, particularly as applies to coarse aggregate, influences the strength of the concrete. Flat, elongated particles pack loosely and generally are inferior to those more nearly cubical or round or egg shaped.

Perfect spheres of equal size, piled in the most compact manner, will leave theoretically about 26 per cent. of voids, so we can see how necessary it is that large particles of aggregate predominate to reduce voids to the lowest possible limit preliminary to incorporating the required amount of cement and fine aggregate in any chosen mixture.

Concrete Mixtures

Definite specified mixtures should not be varied without knowledge of the results that may follow. For example, concrete mixtures are usually referred to as 1:2:3 or 1:2½:5 or 1:3:6, etc. These three figures have a definite meaning. They indicate volumes of the three basic materials of a concrete mixture. The first figure in each case means the quantity of cement used—in other words, "1" stands for one part of cement. The "2" stands for two parts of sand or other fine aggregate. The "3" stands for three parts of pebbles, broken stone, or whatever coarse aggregate is being used.

To attempt to alter these mixtures by taking the one part of cement and considering that the two parts sand and three parts coarse aggregate are the same as five parts of coarse aggregate is a common and serious mistake. It is the mistake always made by those who think the use of unscreened bank-run gravel in a certain volume as taken from the pit is just the same as the two volumes of materials separately prepared and afterward combined. For example, a 1:2:4 mixture, which consists, as we have just explained, of one volume of cement, two similar volumes of sand, and four similar volumes of coarse aggregate, a total of seven cubic feet of the three ingredients measured separately, but it will not produce seven cubic feet of concrete. On the contrary, because of the voids existing in the sand and coarse aggregate, no matter how nicely we have tried to grade them, the three bulks of materials when combined with water into a

concrete mixture will total in the neighborhood of 4½ cubic feet of concrete in place. This should make it evident that any attempt to depart from recommended mixtures prepared in accordance with the fundamentals already outlined will produce a weaker concrete than the user expected.

One sack of Lehigh cement

One barrel of Lehigh cement = Four sacks

Lehigh cement is packed in paper and duck sacks, although sold by the barrel. Four sacks make a barrel. A sack of Lehigh cement weighs 94 pounds net, and for all practical purposes is considered as equal in volume to one cubic foot. Therefore, in writing or speaking of cement mixtures, such as 1:2:3, 1:2½:4, or similar ones, it is convenient to think of the various ingredients as volumes of so many cubic feet. The cement (one sack) is one cubic foot and the proportions are secured by the same volume measurement of fine and coarse aggregates.

Mixtures written as 1 : 1½, 1 : 2, or 1 : 3 refer to mortars. In other words, they are mixtures consisting only of cement, sand and water. 1 : 2 : 3 means 1 cubic foot or 1 sack, of cement, 2 cubic feet of sand, and 3 cubic feet of coarse aggregate.

The following table lists some arbitrary mixtures which, from experience, have proved particularly suited for the various classes of work named, providing the principles of selecting and proportioning materials already outlined have been carefully observed:

TABLE OF RECOMMENDED MIXTURES AND MAXIMUM AGGREGATE SIZES

Concrete

	Size of Aggregate in Inches
1: 1: 1 Mixture for	
The wearing course of two-course floors subject to heavy trucking, such as occurs in factories, warehouses, on loading platforms, etc.	½
1: 1: 1½ Mixture for	
The wearing course of two-course pavements	¾
1: 2: 3 Mixture for	
Reinforced concrete roof slabs	1
One-course concrete road, street, and alley pavements	3
One-course walks and barnyard pavements	1½
One-course concrete floors	1½
Fence posts	½
Sills and lintels without mortar surface	½
Watering troughs and tanks	1
Reinforced concrete columns	1
Mine timbers	¾
Construction subjected to water pressure, such as reservoirs, swimming pools, storage tanks, cisterns, elevator pits, vats, etc.	1
1: 2: 4 Mixture for	
Reinforced concrete walls, floors, beams, columns, and other concrete members designed in combination with steel reinforcing	1
Concrete for the arch ring of arch bridges and culverts	1½
Foundations for engines subjected to heavy loading, impact, and vibration	3
Concrete work subject to vibration	1½
Reinforced concrete sewer pipe	½
1: 2½: 4 Mixture for	
Silo walls, grain-bins, coal-bins, elevators, and similar structures	1½
Building walls above foundation, when stucco finish will not be applied	1½
Walls of pits or basements exposed to moisture	1½
Manure pits	1½
Dipping vats, hog wallows	1
Backing of concrete block	¾
Base of two-course road, street, and alley pavements	3
1: 2½: 5 Mixture for	
Walls above ground which are to have stucco finish	1½
Base of two-course walks, feeding floors, pavements, and floors	1½
Bridge abutments and wing walls, culverts, dams, small retaining walls	2
Basement walls and foundations where water-tightness is not essential	2
Foundations for small engines	2
1: 3: 6 Mixture for	
Mass concrete—large retaining walls, heavy foundations and footings	3

Mortars

In making Portland cement mortar, masons find it desirable to add a small quantity of hydrated lime to the mixture so that the mortar will work easier under the trowel or be "fatter," as it is called. In general, the quantity of hydrated lime thus used should not be greater than 10 per cent by weight of the quantity of Lehigh cement in a given batch of mortar. More than this is likely to affect the strength of the mortar.

	Size of Aggregate in Inches
1:1½ Mixture for	
Inside finish of water tanks, silos, and bin walls, and for facing walls below ground when necessary to afford additional protection against the entrance of moisture (To pass through No. 8 Screen)	
Back plastering of gravity retaining walls (To pass through No. 8 Screen)	
1:2 Mixture for	
Facing block, ornamental, and other concrete products	¼
Wearing course of two-course walks, floors subjected only to light loads, barnyard pavements, etc.	¼

	Size of Aggregate in Inches
1:2½ Mixture for	
Scratch coat of exterior plaster (To pass through No. 8 Screen)	
Fence posts when coarse aggregate is not used	¼
1:3 Mixture for	
Intermediate and finish stucco coats (To pass through No. 8 Screen)	
Concrete block when coarse aggregate is not used	¼
Concrete brick	¼
Concrete drain tile and pipe when coarse aggregate is not used	¼
Ornamental concrete products	¼

The ideal concrete mixture is approached in the mixtures recommended in the foregoing tables, assuming that the sand and coarse aggregates have been prepared with particular reference to grading. It will be noticed in these tables that there is a rather definite relation throughout between the volume of sand used with a certain volume of pebbles. That is, the quantity of sand approximates or in some cases is equivalent to half the volume of coarse aggregates used. This volume of sand, when mixed with the amount of cement called for (and water), in every instance makes a quantity of mortar sufficient to slightly more than fill the voids or air spaces in the bulk of large aggregate.

Quantity and Quality of Water

One of the most important factors in concrete, mention of which has purposely been left until this point, is the quantity of water used in the mixture. Quality also is important. The water must be clean, free from silt and clay, should not be alkaline or acid, should not have oil floating upon it—in a word, might be described as of a quality fit to drink. If it meets that requirement, it is suitable for concrete. However, quantity of water used in a mixture is of greater importance. Too much or too little prevents maximum strength of concrete possible from the proportions of materials being used. Comparing one extreme with the other, too little water within certain limits is better than too much. The latter tends to "drown" the cement, and results in weakening the concrete, just as would result from leaving out so much cement.

As every one knows, the product concrete as we see it everywhere today could not exist were it not for the fact that cement in contact with water undergoes a change that causes it to harden. Therefore, when the materials of a concrete mixture are combined with water, the action taking place between the water and the cement develops the hardening properties of the latter and causes it to bind or literally cement the particles of sand and pebbles together into a solid mass. This transformation, often referred to as "setting," but more properly as hardening, is in reality a chemical change brought about by the combination of cement and water. Technically, it is a form of crystallization otherwise described as "hydration." Too little water, therefore, makes it evident that the full cementing or hardening properties of all the cement used in a certain mixture cannot be developed or utilized; while, on the other hand, if too much water is used, the same hardening property is interfered with. It is impossible to specify a definite amount of water to be used in every particular instance. The reasons for this are probably partly evident to the reader. For example, sand and stone as used at the time of preparing a concrete mixture contain varying quantities of moisture which must be taken into consideration when adding water to the mixed materials. If the aggregates have been exposed a long time to sun and wind, they are naturally dry and will take up more water. If they have been exposed to rain recently, less water need be added. Under average conditions, assuming that a concrete mixture consists of 1 sack or 1 cubic foot of cement, 2 cubic feet

of fine aggregate, and 4 cubic feet of coarse aggregate, the minimum quantity of water that will be practical to use will be about six gallons. This must not be taken as invariable because of influencing factors previously given. The effort should be to use the least quantity of water that will produce a workable mix.

If 20 per cent. more water is used than that required for maximum strength, the strength of the resulting concrete will be reduced by about 30 per cent.; if 30 per cent. more water is used, only about one-half the possible strength of the concrete will be realized. Not only does an excess of mixing water reduce strength and resistance to wear or abrasion on floors or other pavements, but it amounts to a needless waste of cement. For plastic concrete the use of one pint of water more than is necessary in a one-sack batch produces the same reduction in strength as if we should leave out two or three pounds of cement.

In most types of construction we cannot use concrete as dry as that giving maximum strength, since more water must be used in order to secure a workable concrete. It is most important that we sacrifice as little strength as possible in order to secure the necessary workability, by using the smallest quantity of mixing water that will produce a concrete which can be placed in the work.

The accompanying table shows these quantities for a wide range of mixtures. It is assumed that the aggregate is graded up to 1½ inches:

Mix		Approximate Mix as Usually Expressed			Water Required (Gallons per Sack of Lehigh Cement)	
Lehigh Cement	Volume of Aggregate after Mixing	Lehigh Cement	Aggregate: Fine	Aggregate: Coarse	Minimum	Maximum
1	3	1	1¼	2½	5	5½
1	4	1	1½	3	5½	6
1	4½	1	2	3	5¾	6¼
1	5	1	2	4	6	6½
1	6½	1	2½	5	7¼	7¾
1	7¾	1	3	6	8¼	8¾

The degree of workability which a concrete mixture must possess may have to be varied slightly, depending on the character of the work for which the concrete is to be used, but the following guide will always apply:

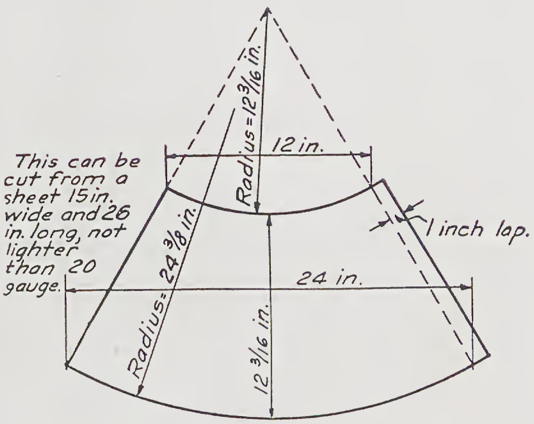
Use the smallest quantity of mixing water that will produce a workable mix

Methods of proportioning, mixing, placing, or finishing concrete which will enable the builder to keep the water content within the lowest practicable limits are of the utmost importance because of the increased strength and resistance to wear thus obtained.

The Slump Test

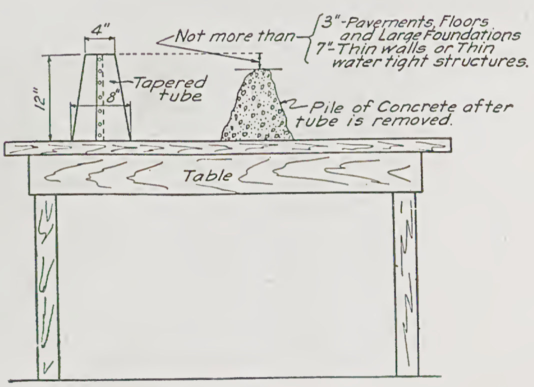
A dependable guide for determining approximate consistency is known as the slump test.

All that is required for this test is a tapered form of heavy tin or sheet metal made up as shown in the sketch on this page. After the concrete has been thoroughly mixed it is placed



Construction of tapered form for slump test

in the tube until flush with the top, being thoroughly settled by working with a pointed iron rod. Then the form is lifted, allowing the concrete to settle or slump. After the pile has stood one or two minutes where there is no vibration to disturb it, its height should be measured and subtracted from the original height of 12 inches. If concrete is being used to lay a pavement, floor, large foundation, or any work that can be tamped, the settlement or slump



Demonstration of slump test

allowed may be between 2 and 3 inches, but should not exceed the latter. If concrete is to be used in thin walls with reinforcement, or in some section that must be watertight, the slump may be between 6 and 7 inches, but should not exceed the latter. If concrete is to be used in the making of such cement products as concrete block, where the mold is to be removed at once, there should be no slump, but as much water should be used as is possible without resulting in any deformation or settlement of the pile after the form has been removed.

Storage of Materials

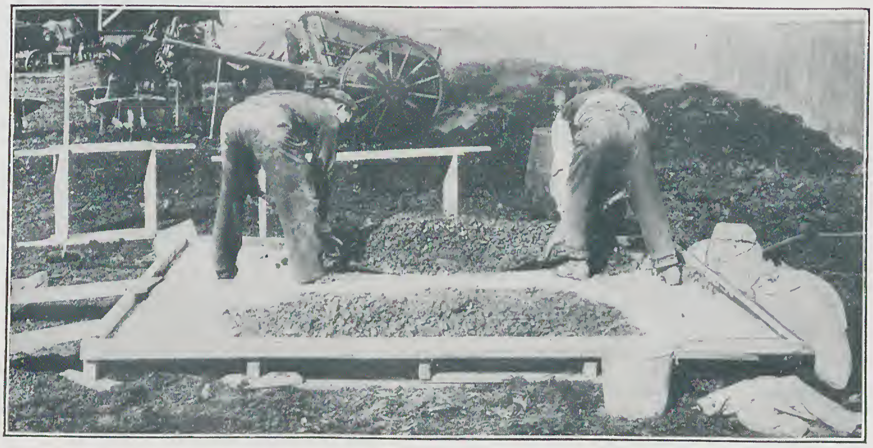
No special methods need be provided for taking care of sand and coarse aggregates on the job other than to see that they are kept from becoming mixed with dirt or other foreign material after they have been prepared for use.

Cement, being very sensitive to moisture, must be carefully cared for, especially if it is kept in storage for any considerable time before use. Even out on the job where any considerable quantity is on hand it should not be piled on the ground, but on an improvised platform of boards laid on pieces of 2 by 4 lumber or something similar to keep it from coming in contact with the soil and from absorbing the moisture at all times present in the ground. Once it has commenced to harden anywhere except in the concrete mixture as intended, some of its natural properties are lost at sacrifice to the strength of the concrete. Provision should also be made for temporary coverings, such as waterproof canvas, in case of a sudden shower. If it is necessary to keep cement in storage for any considerable time, a tight weatherproof shed should be provided, precaution being taken to see that the storage floor is well above ground level so that the cement cannot be affected by moisture; and a weathertight shed means one that has rainproof sides and roof and has no more windows in it (and these should be tight ones) than are necessary to provide only as much light as needed to make handling the cement in and out of the shed convenient. Ventilation should be kept at a minimum because the atmosphere contains varying quantities of moisture, depending upon weather conditions.

Cement that has been stored for considerable time in high piles may develop what is known as "warehouse set" or caking. This is noticed in sacks at the bottom of tall piles and is due to the pressure of sacks above. If the hardening noticed is nothing but that due to the pressure mentioned, mere handling of the sacks by rolling them or by dropping them gently on the warehouse floor will break up this caking. If any cement being used contains lumps which cannot be readily crushed in the hand, it is evident that the cement has been affected by moisture, and such lumps should be screened out when proportioning a mixture.

Empty Sacks

In selling Lehigh cement a charge is made to the dealer for cloth sacks and the dealer passes this charge along to his customer. This is only a temporary charge, because if the sacks



Platform for hand mixing of sand, stone, cement, and water

In hand mixing it is common to turn materials several times until all the ingredients have been thoroughly mixed

are carefully handled, as they should be, they may be returned to the dealer and will be paid for by him in the same amount as charged out.

The dealer may return them to the Lehigh Portland Cement Company for the same credit.

It is particularly important that in handling cement sacks they be well shaken out and kept from becoming wet, because there is always enough cement in the cloth fabric to cause hardening if wet, and sacks are thus rendered worthless for credit. They should be opened carefully so as to avoid tearing, for if they become damaged in this way they are not returnable.

Hand Mixing

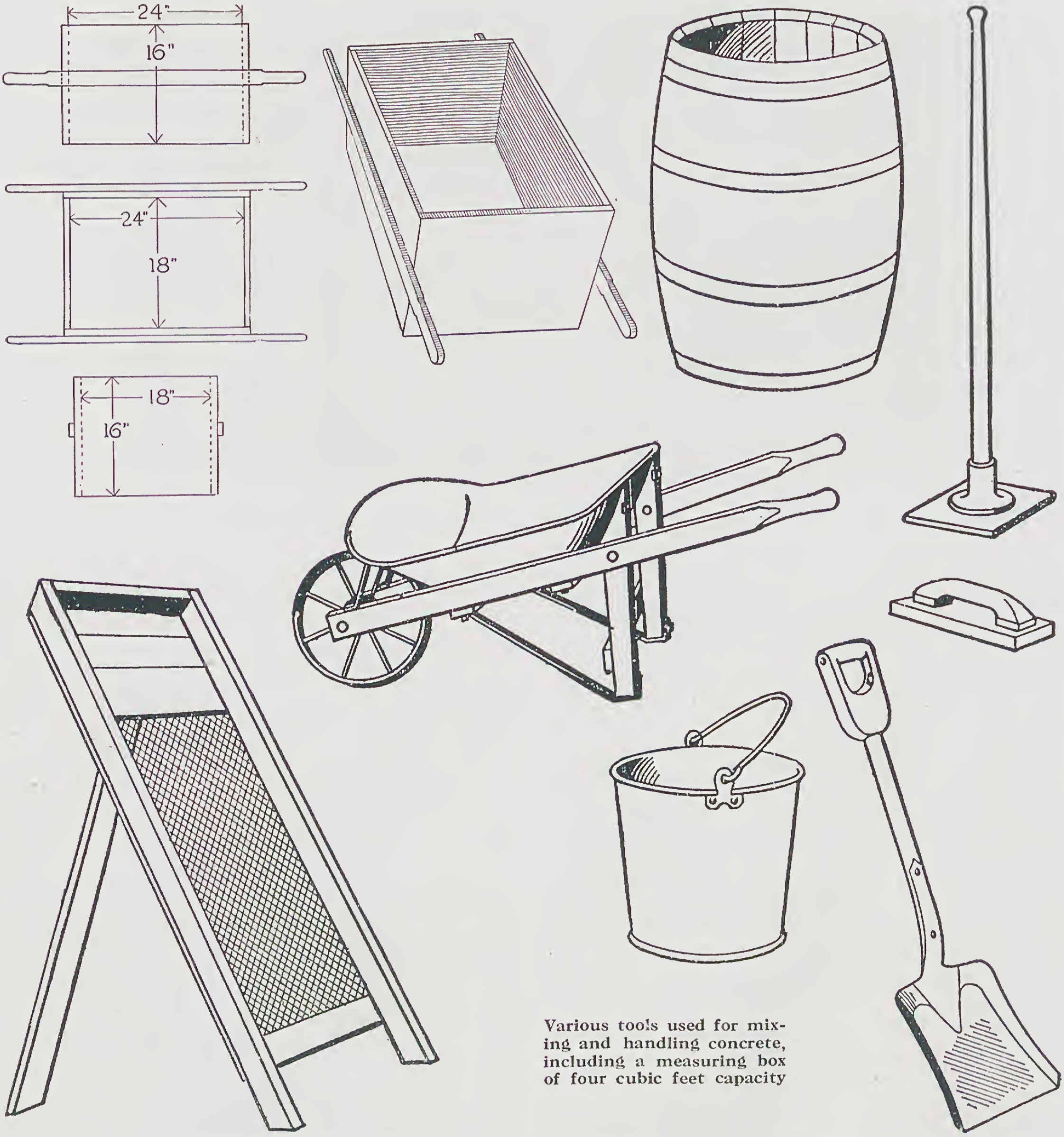
After having selected and properly prepared and proportioned the materials composing a concrete mixture, the several ingredients must be mixed together in a definite manner. This may be done either by hand, using preferably square-end shovels, or by machine. It is characteristic that the use of concrete requires relatively few special tools. In hand mixing about all that is needed is a mixing platform, usually 8 by 10 feet square, made of 1 or 1¼ inch lumber, dressed on one side and preferably tongued and grooved, so as to furnish a smooth, tight surface. This floor should be nailed to 2 by 4's set up on edge, three or four such strips being used to make a rigid platform to work upon. It is also well to put 2 by 2 or similar strips around and above three sides of the platform, to prevent shoveling materials off when mixing, also to prevent water, when added to the materials, from carrying cement away from the mixture.

In hand mixing it is common to turn the materials several times—usually three or four times—until all the ingredients have been thoroughly mixed, as indicated by uniform color of the resulting mass.

Tools Needed

In addition to the mixing platform, shovels, pails, or a hose, if running water is available, wheelbarrows for moving the concrete from the platform to the place where it is to be deposited are about all that are needed.

In order to facilitate hand mixing some definite method like the following should be employed: First measure the required quantity of sand for a certain batch on the platform. On top of this place the required quantity of Lehigh cement. These two materials are then turned a number of times until there is no evidence of streaks of brown and gray, which is a sign that mixing has not been thorough. After this mixing level out the combined sand and cement to a thin layer on the platform and add the required number of cubic feet of pebbles or broken stone. Usually these are wet slightly before placing on top of the sand-cement mixture. The broken stone and sand and cement are then turned together several times until they have been fairly well combined, when water should be added slowly by pouring it from a pail or preferably by gentle spray from a hose, the materials in the



Various tools used for mixing and handling concrete, including a measuring box of four cubic feet capacity

meantime being turned over and over by a shoveler as water is added.

Good concrete can be mixed as just described, but if any considerable quantity of construction is to be done, hand mixing becomes more or less of a back-breaking job, and that is why most concrete is today mixed by machine. The types of concrete mixers are almost too numerous to mention. It is sufficient to say that they start with types of the small home user's variety, and run through a range of size and style with particular reference to details of mechanical equipment leading up to the almost gigantic ones commonly seen on such large pieces of construction as concrete paving jobs, etc.

For many small pieces of concreting done by the casual worker, the purchase of a mixer is not justified. It is a common practice for concrete users in certain communities to plan personal building projects with a view to securing a community mixer which is rented out to all "stockholders" in the scheme until the cost of the equipment is finally absorbed, and no one who has been a party to the arrangement feels his particular share of the expense. Even after such community use has been terminated, the mixer may be made to return its cost several times by renting it out to other individuals desiring to do concrete work.

Another advantage of machine mixed concrete is the assurance of uniformity, in that

A "community" machine mixer

time and thoroughness of mixing are definitely controlled. Once it has been determined that a certain period of time or a certain number of revolutions of the drum produce a thorough mix, this same efficiency can be repeated in every subsequent batch. Of course, in using a mixer certain rules must guide. The drum should not be revolved more rapidly than is recommended by the manufacturer of the machine, who has determined its best average working speed. If the drum is revolved too rapidly, the materials tend to cling to the inner surface of the drum and will not be tumbled about sufficiently to be thoroughly mixed. Most concrete is not mixed long enough. If all concrete mixtures were agitated in the mixer drum for not less than one minute, and preferably one and one-half minutes, the average quality of concrete work in general would be immeasurably improved.

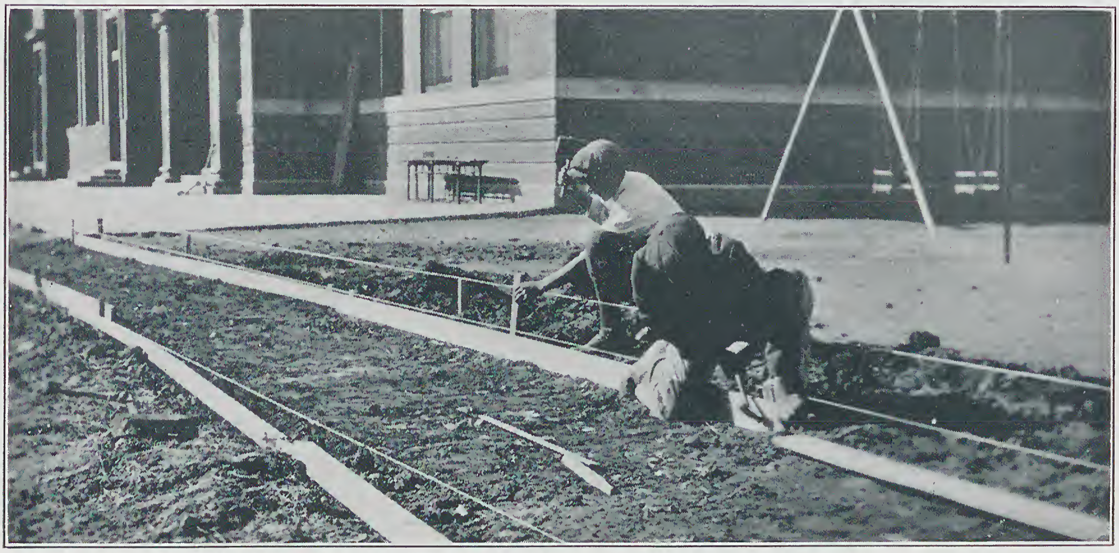
Forms for Concrete Construction

WITHIN half an hour or less a concrete mixture, if left undisturbed, will commence to harden. In order that the plastic concrete shall assume the shape intended it must be quickly placed in forms. These forms, by their interior shape, govern the surface and other details of the structure.

Forms or molds may be defined as the receptacles in which a concrete mixture is placed soon after mixing so that it can be properly confined while hardening to the required shape.

For a great deal of concrete work the forms required are relatively simple. Usually the only forms required for a concrete walk or driveway are the side strips locating the actual edges of the walk or drive, and perhaps cross-pieces to define the limit of size of the various slabs into which the walk or drive is divided. See illustration on page 164. Forms for such work are therefore usually 2 by 4 or 2 by 6 strips of lumber set on edge and staked firmly in position so that the edges of the concrete will be true to line. In setting these forms it is necessary to level their upper surface or, if the work is not intended to be exactly level, then to set them so that the finished concrete surface will have the grade or slope desired. In building a concrete walk or laying a barnyard pavement or concrete feeding floor, it is customary to give the surface a slope in either one or two directions, thus providing surface drainage. The top grade of forms which are used as a guide for finishing should be set in accordance with the slope or gradient of the finished surface. Form making for simple structures is not necessarily difficult and involves only limited carpenter skill.

Since the greater portion of concrete work is seldom duplicated, most forms for concrete work are made of lumber. There are standardized systems of forms intended for use where repeated setting for similar classes of work can be done. In such cases forms are often made of sheet steel riveted to angle irons



The only forms for a concrete walk are side strips locating the actual edges

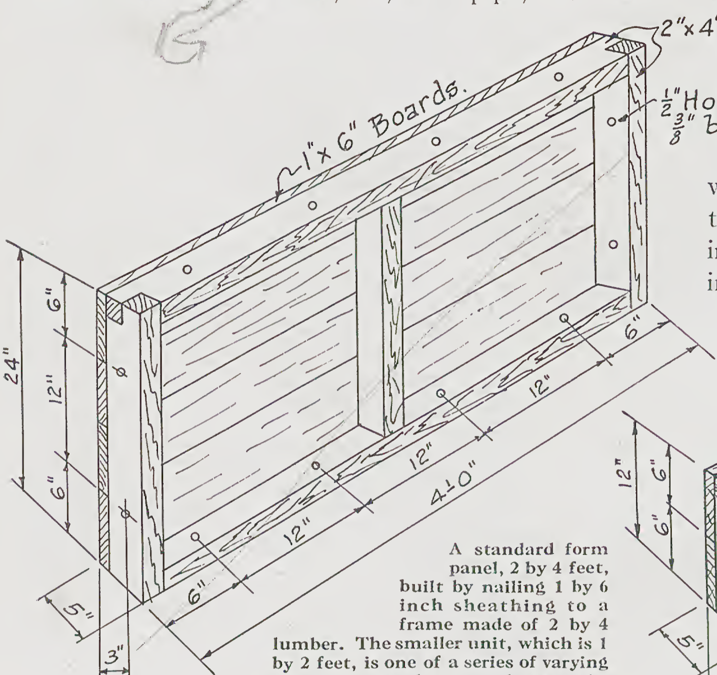
to give them stiffness and prevent bending from the weight of the concrete.

Where wood is used for forms, Norway pine, hemlock, or other lumber of similar quality and grade, is used for economy and because it is easy to work. In some cases wooden forms are metal lined for the two-fold purpose of making them last longer and insuring a better surface of the finished concrete. Metal molds are also used in some classes of concrete work. The all-metal mold is best represented by those portions regularly a part of machines for the manufacture of concrete block, tile, sewer pipe, etc.

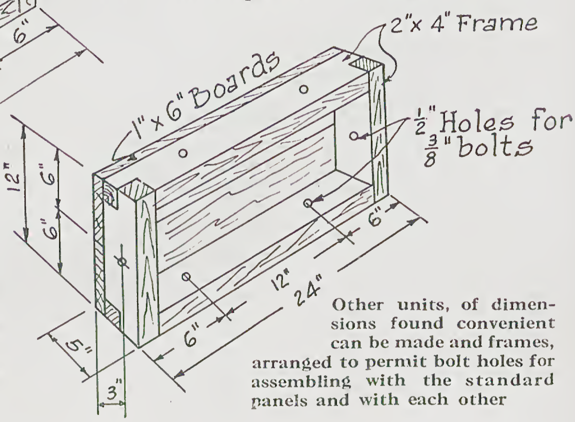
Forms are important because the appearance of the finished work is governed to a considerable degree by the care with which they are made and set up.

Therefore, good workmanship on forms is well repaid.

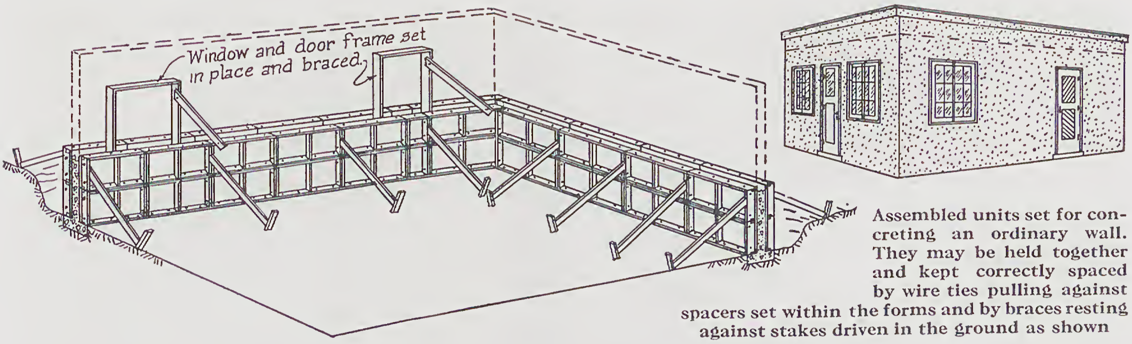
For work that is not to be exposed to view, such as an interior wall surface that ultimately is to be covered by sheathing and plaster, rough lumber will serve for form sheathing. Otherwise lumber dressed on one side, and preferably tongued and grooved, is to be preferred. For such concrete work as foundation walls below ground level, forms are seldom used if the earth is firm enough to stand without caving. An exception to this is where the excavation for the foundation is so deep that dumping concrete into the trench will throw down soil into it and upon the concrete.



A standard form panel, 2 by 4 feet, built by nailing 1 by 6 inch sheathing to a frame made of 2 by 4 lumber. The smaller unit, which is 1 by 2 feet, is one of a series of varying sized units used to supplement the larger unit, which is a standard



Other units, of dimensions found convenient can be made and frames, arranged to permit bolt holes for assembling with the standard panels and with each other



Assembled units set for concreting an ordinary wall. They may be held together and kept correctly spaced by wire ties pulling against spacers set within the forms and by braces resting against stakes driven in the ground as shown

Forms must have the strength required to support the mass of concrete involved in the section being built. It naturally requires less studding and bracing to make rigid forms for a floor 4 inches thick than for a floor 10 inches thick. Forms must not be yielding or the weight of concrete will cause a sag in the work.

Seasoned Lumber

Air-seasoned lumber is better for forms than green or kiln-dried. Green lumber is likely to dry out after being assembled in the forms. This will cause joints to open, resulting in the loss of cement, which would be carried away by water seeping through openings. Kiln-dried lumber is likely to bulge and swell when the wet concrete comes in contact with it, thus forcing the forms out of line and resulting in an irregular surface. Where true surfaces are imperative, form sheathing, whether dressed on one or on both sides, must be of uniform thickness. Inequalities of thickness will cause irregularities on the finished surface.

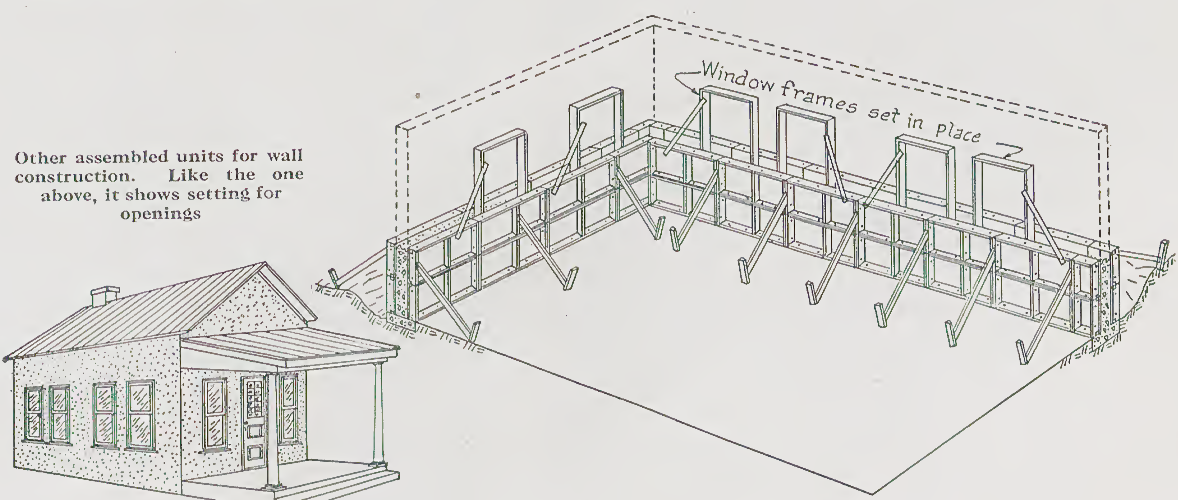
Sheathing should not be more than four inches wide, although if of good clear lumber, may be 6 inches wide. The studs and bracing will be of varying dimensions in accordance with the weight they must carry.

Considerable economy results from planning forms carefully before cutting lumber. Planning involves careful study of the working drawings of the structure or object to be built. It should be remembered that the inside surfaces of the forms lie against the concrete and thus reproduce the design, shape, or details intended. A projection designed on the structure calls for a depression in the face of the form to produce that projection. In other words, the form surface or interior face must be the reverse of the finished concrete surface or face.

Standard Panels

Often forms can be planned in such units or sections as to permit repeated use on similar portions of structures other than the ones for which first made, or they may be used on various other parts of the same structure, thus economizing on form cost. For example, most small foundations are made by setting up a variety of standardized wooden panels, staking

Other assembled units for wall construction. Like the one above, it shows setting for openings



and bracing them securely in place and position with reference to opposite sections and placing concrete in the space thus provided rather than by building special forms for each particular job. In that way economy of lumber results, because in such simple work as a house foundation these standardized sections or panels can be used repeatedly. Care and forethought given to planning forms will, therefore, result in economy of labor and materials.

For silos, grain tanks, chimneys, and some other circular structures, as well as certain rectangular ones, metal forms have been devised. Such forms are in general use by silo builders and by general building contractors specializing in concrete construction.

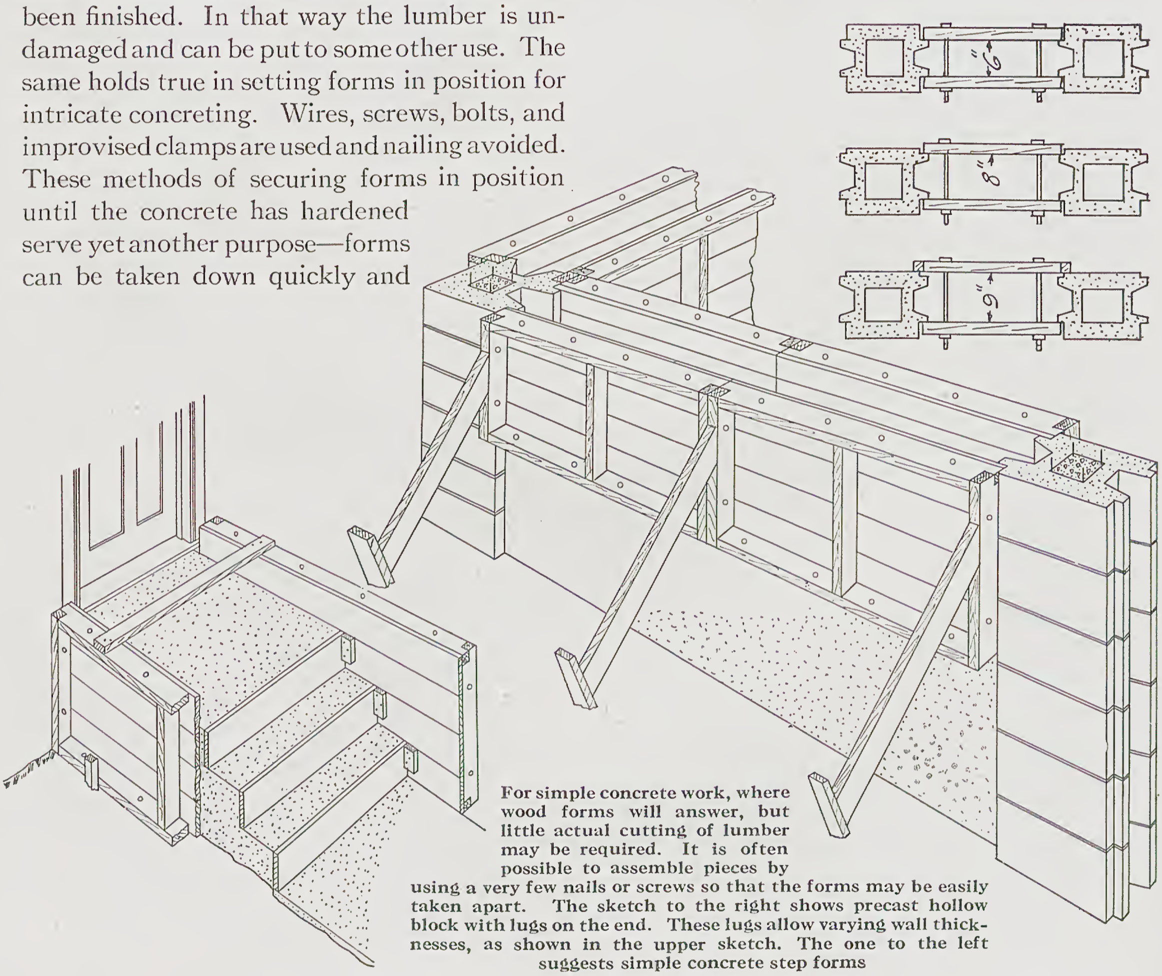
Assembling Forms

For simple concrete work it will often be found possible to assemble pieces by using very few nails or a few screws instead, making it easy to take forms apart when the work has been finished. In that way the lumber is undamaged and can be put to some other use. The same holds true in setting forms in position for intricate concreting. Wires, screws, bolts, and improvised clamps are used and nailing avoided. These methods of securing forms in position until the concrete has hardened serve yet another purpose—forms can be taken down quickly and with less damage to green concrete than if hammering is done to release form parts or sections.

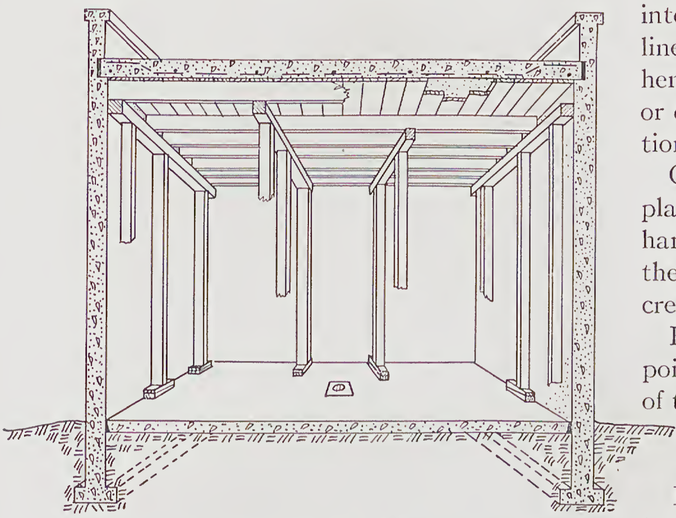
Avoid Dry Forms

It is customary to wet forms down during extremely dry weather before placing any concrete, so that the dry lumber will not absorb water from the concrete and thereby deprive it of moisture needed in its hardening. Each time after being taken down the forms should be thoroughly cleaned so as to leave them in condition for the next use.

The forms for many small objects are often made of soft white pine thoroughly kiln dried because of the ease with which it may be worked. To prevent it from swelling, the lumber or the finished form is thoroughly treated or saturated with crude oil, which keeps the wood from absorbing moisture and thus warping out of shape. This oil treatment also prevents the concrete from sticking to the form.



For simple concrete work, where wood forms will answer, but little actual cutting of lumber may be required. It is often possible to assemble pieces by using a very few nails or screws so that the forms may be easily taken apart. The sketch to the right shows precast hollow block with lugs on the end. These lugs allow varying wall thicknesses, as shown in the upper sketch. The one to the left suggests simple concrete step forms



Forms used for the construction of a concrete roof should be supported by plenty of strong posts. The bottom of these posts should rest on double wedges, as shown above, to facilitate easy removal. Few nails should be used

Struts or posts supporting the actual forms or form sections for roofs and arches must be so set as to permit easy removal. Wedges that can be knocked out are generally used. See above.

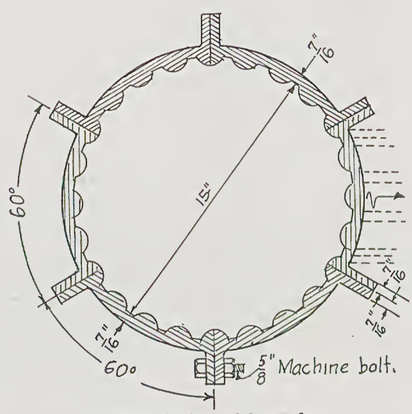
Cylindrical Forms

Forms for cylindrical columns and irregular objects must be made in sufficient sections so that at no point will any part of the form bind or cling to a projecting part of the concrete when removing it. Molds or forms for fluted columns may have to be divided into eight or more sections to make removal easy. Even the mold for a truly cylindrical object may have to be divided into three or more parts. If a form of this kind were to be divided merely into two parts, it is possible that the division line would not make the supposed halves equal, hence one section would bind or cling to post or column. This applies with but few exceptions to all circular molds or forms.

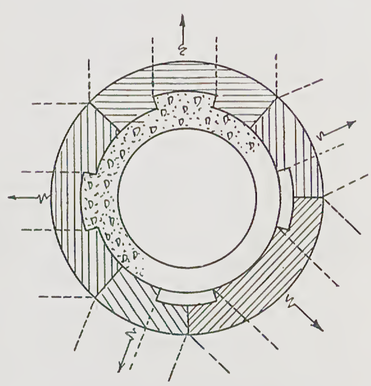
Cores for objects that are hollow must be planned so that they can be withdrawn without hammering or without exerting any force on the object that might tend to break the concrete while it is soft.

Below are examples illustrating some of the points just brought out and showing how forms of the type mentioned must be planned so that the various sections can be easily removed.

Form removal should be done only when it is known that the concrete is strong enough. For some classes of work, such as ordinary walls for buildings only one story high, it may be possible to remove forms at the end of twenty-four or thirty-six hours, providing the concrete is to bear no load except its own weight. However, there is no invariable guide for form removal, but it is best to *leave all forms in place a little longer than seems necessary.* Particularly is this true in cold weather, because concrete then hardens very slowly.

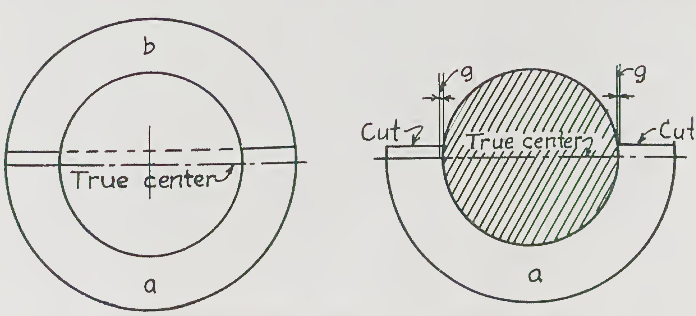


Sectional plan of form for fluted column

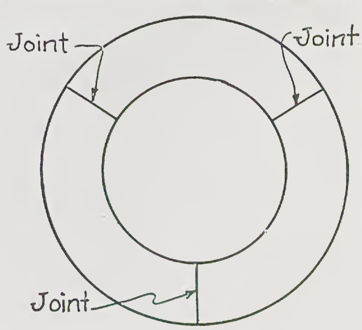


Product with projecting surfaces Correct and incorrect methods

Forms for cylindrical columns must be made in sufficient sections so that at no point will any form bind or cling to a projecting part of the concrete when it is being removed



Incorrect method of making joints for circular forms



Correct method

Reinforcing Concrete

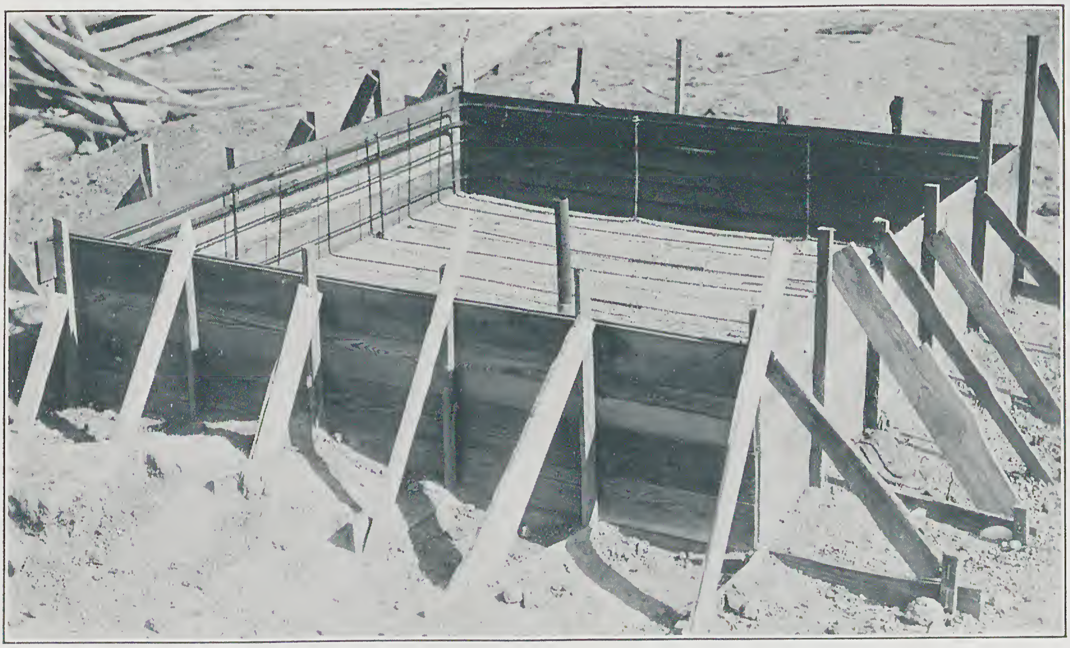
THE incorporation of steel in a concrete mass makes it reinforced concrete. The reinforcement may be in the form of rods, wire, or mesh. Plain concrete is made without reinforcement, and is best illustrated by ordinary foundation work. This concrete is placed in a mass and subjected to no strains other than that of compression, namely, carrying loads placed directly upon it. In this respect concrete is remarkable for its great strength. It has an unusual ability to resist great crushing forces. But when concrete is used in thin sections, such as overhead floors, beams, or slabs, it is subjected to tension, that is, bending strains, and unless reinforcement is embedded, it will not carry loads required.

The principle of reinforcement can be illustrated in a simple fashion. If we make a cube of concrete, say one inch square, it will support a relatively large load placed directly upon it without crushing. If we were to take this cube of concrete and increase its dimensions by changing it into a column, say one inch square and ten inches high, it might still sustain a considerable load, but other strains would be brought to bear upon it, and because of its length these strains might tend to bend it and thus exert what is known as the force of tension, the strain induced by pulling and bending.

If we took this same column 1 inch square and 10 inches long and laid it in horizontal position supported only at its ends, it would not carry anywhere near the same load placed at its center or any point between the two ends as it would support standing in a vertical position acting as a column. Also if we took this "beam" of concrete and fixed it so that it would be supported at one end only, allowing the other end to project unsupported, the beam would not support much load at its free end and would not have to be made very long by comparison with its cross-sectional area to cause it to break of its own weight. The breaking of the beam, whether loaded at its center or at any point between the two supporting ends or by breaking due to its own weight when supported at one end only, is due to tension or pulling strains.

Strength of Concrete

The compressive strength of concrete is approximately ten times its tensile strength. Reinforcing metal of suitable size and shape properly embedded in the concrete provides the strength which concrete lacks in tension and therefore the use of concrete for beams and floors as well as for walls or any other parts of a structure is practical.



In reinforced concrete the rods are placed in certain positions so that the steel thus embedded will take the tension and safely carry the load

The reinforcement placed in it is effective because, properly mixed, well-placed concrete of correct consistency adheres to the steel or forms a bond with it and thus holds the steel in fixed position so that when loads are applied on the concrete the steel immediately takes its share of the strain, and prevents the concrete from failing.

Types of Reinforcement

Reinforcement, as already intimated, may be in the form of steel rods or various kinds of mesh or fabric. The rods may be round, square, or variously deformed, the last type of rod reinforcement being found in the market in considerable variety and usually subject to some patent control. The object of deforming the rods either by rolling lugs on or making depressions in their surface is for the purpose of increasing the "mechanical bond" between the concrete and steel.

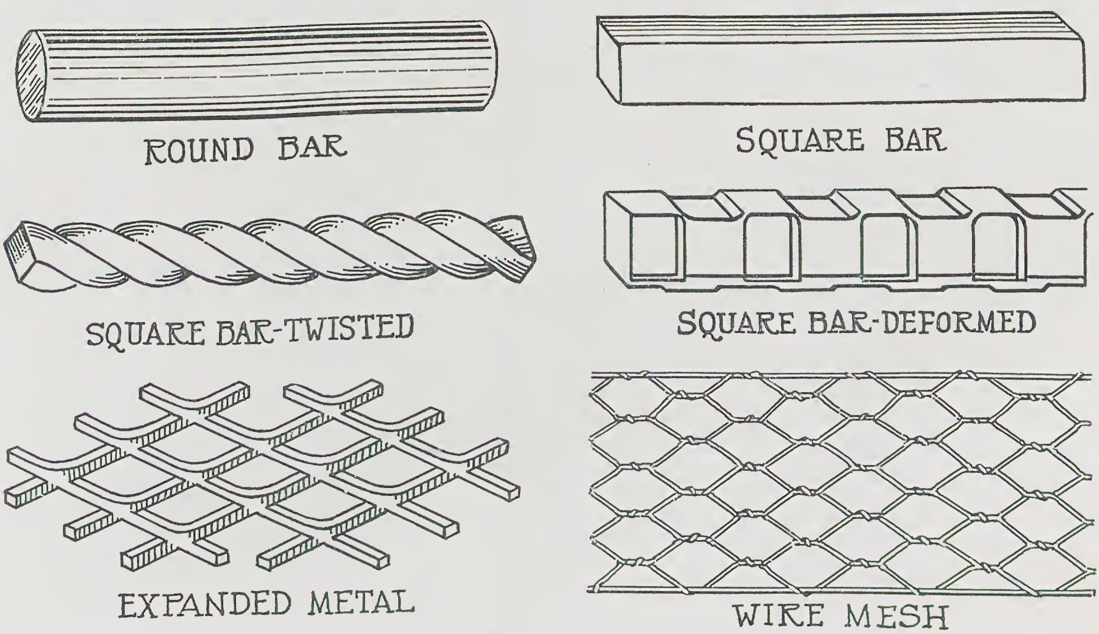
Mesh or fabric of various kinds for concrete reinforcement are sold under different trade names. The term "expanded metal" is applied to a type of reinforcing fabric made by regularly slotting sheets and then stretching or "expanding" these sheets until the slots open and cause the sheet to appear in the form of mesh or netting.

Other types of reinforcing mesh are not unlike wire fencing, with the exception that the mesh openings are of uniform size, so that a definite total weight of reinforcement can be determined and provided for any particular reinforced section.

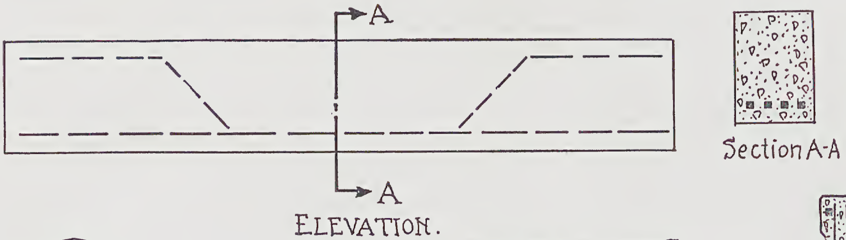
The principle of reinforcing can be illustrated in several simple ways. Probably the simplest illustration is for one to take a small tree branch, say ½ inch in diameter, and bend it across his knee. The part next to one's knee or toward one while being bent will show that the bark on that surface is wrinkling, in other words, being compressed, while the surface farthest away will show that the bark is cracking, or, if bending continues far enough, the fibers of the wood will break, while the inner portion will still remain unfractured. In other words, the outer section of the branch has been compelled to take tension, could not stand it to the limit exposed, and therefore the fibers were torn asunder, while the inner side of the branch shows compression, as illustrated by the wrinkling of the bark. If a steel wire could have been embedded and positively fixed in the branch before bending, the break would not have occurred until the wire broke.

Position of Reinforcement

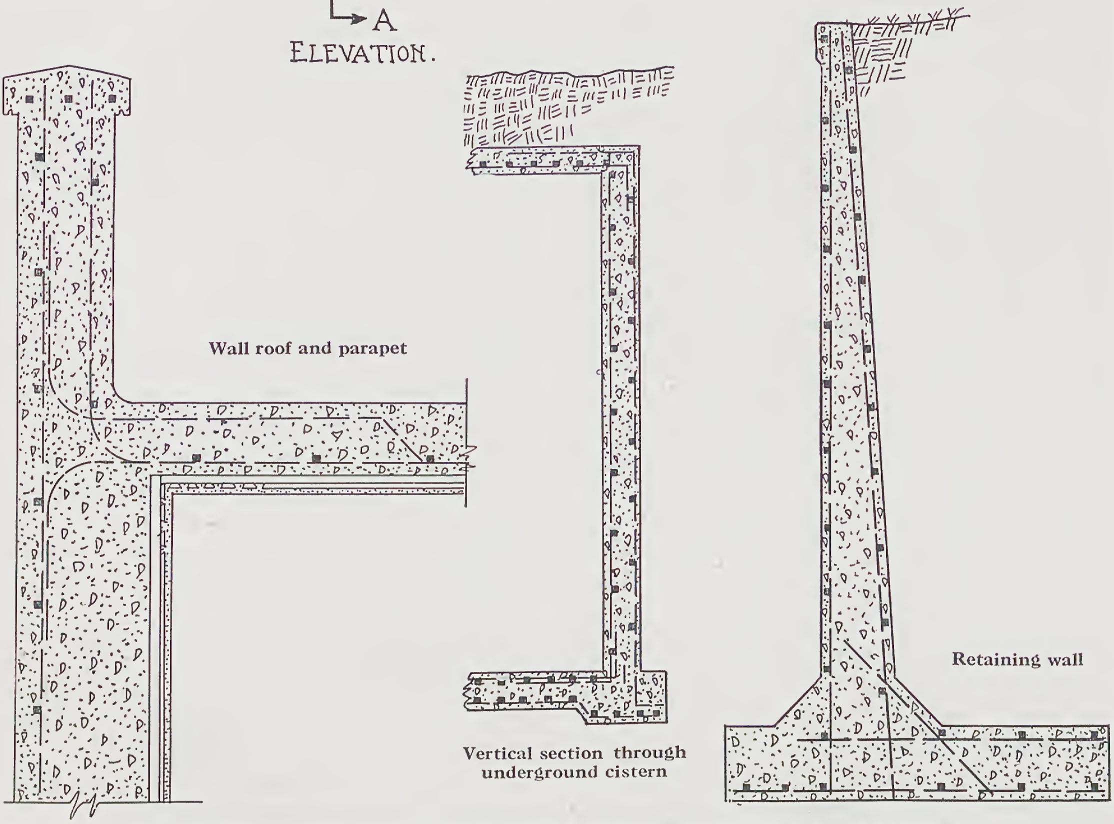
In reinforced concrete beams and floor or roof slabs, rods of suitable size and number are placed in a position determined by engineering computations so that the steel thus embedded will take the tension and make the beam or slab carry safely the load for which it was designed.



Reinforcing materials



Concrete beam supported on both ends. Rods placed along bottom, where tensile strength is required. Alternate rods bent up as some pull occurs at the top, near supporting points



Reinforcement is placed near the opposite face to that against which the load is applied

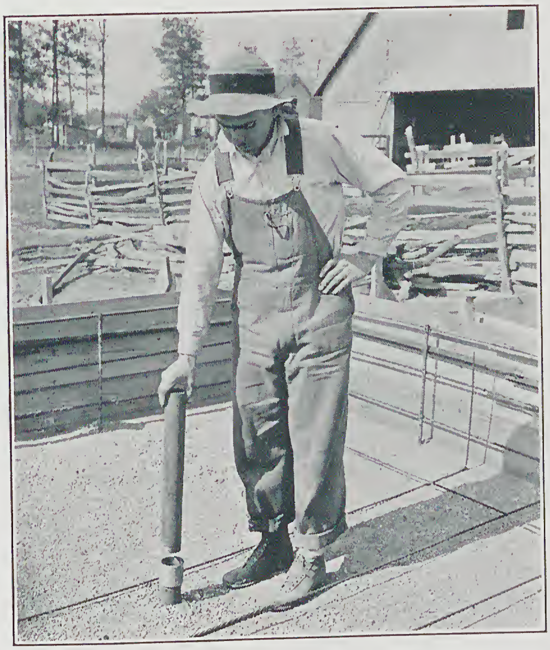
The principle of reinforcing a column can be illustrated in a simple fashion also. Make a cylinder of thin paper,—the thinner the better,—and carefully fill this cylinder with sand while holding this paper "form" in an upright position with one end resting on a table top. After this paper cylinder has been filled commence applying pressure to the upper end with the hand and it will not be long before sufficient pressure will have been applied to cause the thin shell or "form" of paper to burst.

If, instead of paper for this form, we had used cardboard, it is evident more pressure would be needed to burst the cylinder casing. In other words, this casing acted as reinforcement to prevent the effect of bursting pressure.

If the cylinder is made of tin and filled with sand, still more weight or pressure will be required to cause the tin casing to burst.

These simple progressive illustrations are typical of the practice of reinforcing columns by hooping vertical rods, vertical rods being used in connection with the hooping to prevent the bending due to lateral pressure or load or, as it is scientifically referred to, "eccentric loading."

These examples are homely ones, intended only to make the principles clear. The subject of reinforced concrete is an engineering one and the design of reinforced concrete depends upon a knowledge of the engineering principles involved. The mathematics of the subject are complicated and an understanding of them is not within the capabilities of the person without engineering training. This is no bar to the actual performance of concrete construction because plans for all ordinary types of concrete construction are readily obtained, and if not exactly suited to a prospective builder's requirements, form the basis of redesign that can readily be done by an architect having a knowledge of reinforced concrete.



Outer forms and reinforcement in place for building concrete stock watering trough. Illustration shows how provision has been made for overflow pipe, which also serves as outlet by unscrewing the pipe, the bottom of which will be exactly level with the floor when concrete has been placed

In doing any concrete work that calls for reinforcing, care must be taken to see that the reinforcement, whatever its form, rods or fabric, be placed in exactly the position called for by the plans. There are two reasons for this: First, the position shown in the plans is the one determined as best to secure its full effectiveness with relation to economy of actual concrete required in the work. In any kind of reinforced concrete construction where there is a possibility that at some time the structure may be subjected to fire, the steel must be sufficiently embedded in the concrete to protect it. The thorough embedding of reinforcement is also necessary if the desired strength is to be attained.

Care of Materials

Reinforcing material should be carefully cared for while on the job to keep it from becoming coated with grease or other foreign substances that would prevent the concrete from adhering to it. If it has rusted before being used, all rust in the form of dust, and particularly scale, must be removed by brushing with a wire brush or striking with a hammer or in whatever other manner proves effective. Often rods have to be shaped at some point in their length in order to conform to certain details of placing shown in the plans. Whenever reinforcing steel must be bent for that reason, bends should be made gradually so that the steel will not be subjected to sudden stress which might cause small fractures, thus impairing its full effectiveness.

Much dissatisfaction has resulted from some home-made concrete because the beginner has been told by someone who did not know any better that any kind of scrap metal, such as barbed wire, chain, old pipe, etc., would answer as reinforcement instead of the special materials provided and intended for the purpose. The result has been that tanks have cracked and, consequently, leaked; silos have bursted in the same fashion. Almost invariably the concrete itself or the cement has been condemned when the fault was all in the workmanship. Reinforcing steel, whether in the form of rods, mesh, or fabric, is supposed to have a certain chemical composition resulting in giving it certain definite strength and other desirable qualities as a reinforcing material. For that reason it is not likely that rods such as one might obtain from the local blacksmith's shop or fencing fabric from the local hardware store will answer the purpose, nor even be as cheap nor as good as reinforcing material made specially for the purpose. All of the common types of reinforcement can be procured through the local building material dealer.

Length of Rods

Naturally, rods and the various other kinds of reinforcing material used are limited as to length and pieces. It is necessary to splice reinforcement to make it continuous if the section being reinforced is longer than stock lengths of rods. Expanded metal generally comes in sheets; mesh fabric usually comes in rolls. Rods come in definite lengths, governed largely by their weight and also shipping conditions.

When placed in concrete as reinforcement, the ends of mesh should be overlapped 4 inches or more and bound together securely by wire so as to prevent displacement during placing of concrete. Rods should be lapped from fifty to sixty times their diameter. They should have their lapped ends separated enough to permit surrounding everywhere with concrete and thus produce perfect bond or adhesion with the steel. Whenever expanded metal or

wire mesh is used to reinforce small objects, such as flower-boxes, bird-bath basins, fountain bowls, and watering tanks, it is necessary to cut the flat sheets so that the reinforcement can be properly shaped, and afterward the cut edges must be joined to conform to the general lines of the product. This is called developing the sheet of reinforcement. To illustrate this sketches on pages 78 and 79 are shown, intended to represent the plan of laying out reinforcement from a sheet of mesh to be used in a fountain bowl or basin. The greater the diameter of the bowl to be reinforced, the greater the number of radial cuts that are required to enable shaping the reinforcement properly and regularly. An illustration of developing reinforcement in this fashion is to take an orange, cut it in half, then make cuts from the diameter down to the stem, and remove the peeling and lay all of it flat on the table. This example is a counterpart of the sketch.

Steel is used instead of other metal for reinforcing concrete because it has practically the same ratio of expansion as concrete. In other words, all substances expand and contract under changing temperature conditions and the rate of this expansion as between steel and concrete is so nearly the same that the bond between the concrete and steel is not broken. No other metal has so nearly the same ratio of expansion and contraction under temperature changes, therefore steel is used.

Placing Concrete

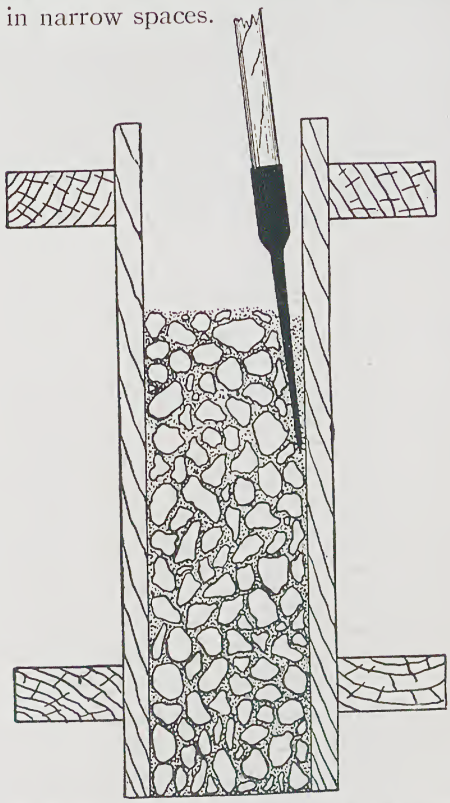
WITH the subjects of selection of materials, proportioning, mixing, providing the necessary forms, and reinforcement thoroughly understood, we can now take up the placing of concrete. Concrete commences to harden very shortly after the water is added. It is therefore evident that as soon after mixing as possible the concrete should be placed in the forms in order that it may assume the shape intended. It is convenient to have the mixing operation carried on as near the place where the concrete is to be deposited as possible. When hand mixing is done, the mixing platform can be moved from time to time in order to make the least handling of concrete necessary. The mixer also can be moved from place to place as it seems desirable to shorten the distance of moving concrete or to make placing speedier and more convenient. On large engineering structures the matter of placing concrete may be considerably varied within a wide range of methods. For the average structure, placing concrete is merely moving it from mixer drum to forms by means of shovels, buckets, or wheelbarrows.

When concrete is being placed in an excavation for a foundation wall, it is well to lay boards or planks along and across the trench so that workmen walking along its edge or wheeling barrows loaded with concrete can dump the concrete without breaking down the trench sides. All concrete work should be so planned that the quantity of concrete to be placed during the working day or whatever time is set aside to the work can be estimated closely enough so that when quitting time comes the job may be left in suitable condition for easily resuming further work. Concrete should be deposited in layers of uniform thickness throughout the enclosure made by the forms. From six to eight inches is the greatest depth that should be placed at one time, because a layer of greater thickness cannot be spaded or tamped to complete compactness. Sometimes concrete is placed so as to complete various sections, the full length of the forms or full height of the concrete section being built, thus making the work practically continuous. Arrange for as continuous concreting as possible to prevent construction seams.

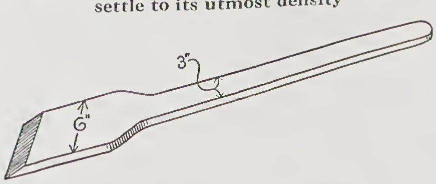
When a dry concrete mixture is used, placing is done by vigorous tamping after the concrete has been placed. If the class of work being done requires concrete containing more water, or what is usually described as quaky consistency, then the concrete is consolidated in the forms by spading. This settles it to utmost density, causes it thoroughly to surround and adhere to reinforcement if reinforcement is being used, and releases air-bubbles that may be entrapped in the concrete. Spading concrete next to form faces is very important, because in that way a dense, even surface is produced, by forcing back from contact with the forms the particles of coarse aggregate

which allow a film of sand-cement mortar to settle next to form faces. Another reason is that thorough spading increases density and hence watertightness.

A convenient spading tool may be made from a piece of hard wood board six inches wide and one inch thick, shaped to have a chisel edge at the lower end and so cut away at the upper end as to form a handle. An old garden spade or hoe may be flattened out and slotted and used in the same manner. Narrower spading tools or sometimes rods are needed when working the concrete around reinforcement and in narrow spaces.



Spading concrete next to form faces causes the concrete to settle to its utmost density



Spader made of a 1" by 6" board

Methods of placing concrete vary somewhat in accordance with the kind of work being done. For walks, floors, and similar pavements the concrete is usually carried from the mixer or mixing platform in wheelbarrows and is placed on the spot where it is to be leveled off. Particularly when concreting troughs, watering tanks, silos, and other structures which should be both air-and water-tight, it is necessary to carry on concreting as continuously as possible so as to eliminate construction seams. Many jobs cannot be completed within a working day. Therefore the plane where work has stopped one day must be left in such condition as to make it easy to resume work later and leave no effect of a seam or lack of union between the two planes. This is usually done by roughening the concrete in the form when work is stopped, then immediately before resuming work painting the old surface with a paint made of cement and water, mixed like thick cream and applied with a broom or swab and immediately following this by placing concrete in the regular way. Between narrow forms concrete has to be placed in thinner layers because of the difficulty of spading in the narrow space. Under such conditions only one form section should be boarded up to full height, leaving the other to be boarded up as concreting progresses.

Precautions must be taken not to allow concrete to drop through too great a height when placing. From six to eight feet is the maximum distance. If allowed to fall a greater distance, there will be some separation of materials, with the result that the finished work will show pebble pockets on the surface.

Central Mixing Tower

On large work, involving the placing of a considerable volume of concrete, a central mixing plant is usually erected and towers provided to elevate the mixed concrete to such a height that it can be distributed over a wide area by means of chutes or spouts. Such methods of placing, where practicable, represent great economy of time. However, the method as applied on certain jobs is often deserving of just criticism because, in order to facilitate speeding up of the work, the concrete is mixed too wet for the purpose of causing it to flow more rapidly or readily down the chute. This bad practice is often the result of attempting to make a central plant serve too large an area at one setting, and in that case the chutes or spouts used lie at such a small angle with the horizontal that concrete will not flow into place unless made too wet. Never forget what has been said elsewhere about the importance of the correct quantity of water in concrete.

Concrete work should be wet for several days after placing

Curing Concrete

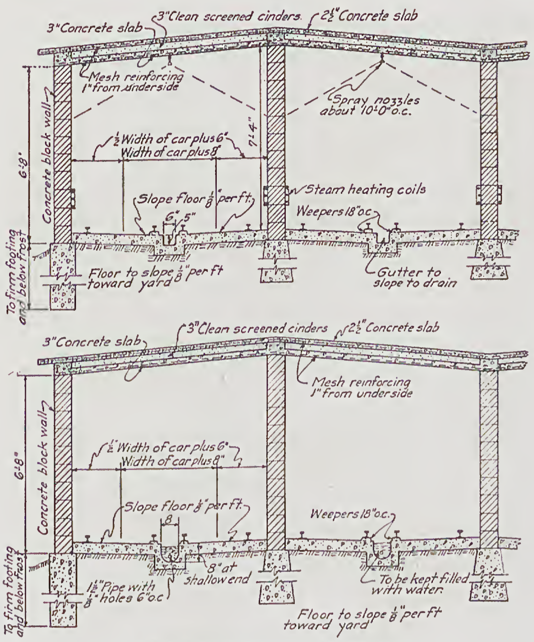
THE majority of people seem to have the impression that the hardening of concrete is a drying process. This is not true. Attention has been called to the fact that it is the combination of the water with the cement that causes concrete to harden. Forms are taken down and the work is exposed to wind and sun in the belief that such treatment is the one which should be given to complete hardening. This practice deprives the concrete of a great deal of added strength it would have attained had proper protection been given to the work for a few days after the last concrete was placed. Exposure to drying influences weakens concrete structurally, and deprives concrete floors, walks, and other pavements of strength that would increase wear resistance. Instead of being neglected, proper curing of concrete should be universally practised.

Curing Completes Hardening

Walks, floors, and walls have a large surface area exposed to the atmosphere, sun and wind causing evaporation. This robs the concrete of a vital element. Wall forms furnish a measure of protection to concrete walls above ground. The earth of a foundation trench in contact with the concrete provides all the protection the foundation needs while curing. Work above ground, however, should be wet down for several days by drenching with water in order to complete hardening by keeping the concrete moist. Floors, sidewalks, street, and road pavements are protected by a layer of moist earth, sawdust, or other moisture-retaining material applied as soon as it can be placed without marring the surface of the concrete. The best method of pavement protection, where it can be applied, is to flood the surface with water. Floors can almost always be protected in this way by throwing up a small earth embankment around their edges to retain the water. Highway pavements are cured in the same manner.

Steam Curing Chambers

Concrete block, concrete brick, and concrete structural tile, fence posts, sewer pipe, drain tile, and all other so-called concrete products, are preferably cured by keeping them in the presence of moist heat, such as is provided in so-called steam curing chambers. The manufacture of all such products is seldom carried on by the home worker except on a very small scale, and to him the steam curing method is not practicable. Therefore, ordinary water



A concrete steam curing chamber

curing by spraying or by keeping the products covered with wet straw or other moisture-retaining material is the alternative method.

Products plants are equipped with steam curing chambers. These contain narrow gauge car tracks to permit running into them small cars loaded with the finished products as removed from the molds or machines. The chambers are then sealed and moist steam turned into them, the chambers kept at a constant temperature for forty-eight hours, during which time, because of the steam curing conditions, the products acquire a uniform hardness not possible to attain in any other way.

The home worker should always bear in mind the importance of curing concrete in some one of the ways just described. Such curing is well repaid in the greater strength, durability, and wear resistance of the concrete, particularly as applied to driveways, walks, and such pavements as are laid in barnyards and in hog lots for feeding floors. During moderate weather, where floors are being laid indoors, the structure enclosure makes extreme measures of curing unnecessary. Occasional sprinkling of the concrete surface for several days will increase its strength.

Waterproofing of Concrete

WATERPROOFING is relatively simple and should always be built into the concrete. The general impression is that concrete is porous, but if the fundamental principles governing concrete practice are followed, this material can be made impervious to moisture.

Concrete is Watertight

The fact that concrete, well made, properly placed, and protected while curing, is from a practical aspect watertight, is proved by many structures long used successfully as containers for water, oil, and other liquids. Thin sections of concrete may contain small fissures that will permit seepage. Such sections are almost invariably porous in spots because of the difficulty of placing thin sections of concrete in forms so as to secure uniform density. There are countless structures, such as tanks, reservoirs, and standpipes, which have never leaked and which disprove statements that concrete cannot be made watertight.

Primarily several fundamentals govern the success or failure to attain watertight concrete. If the concrete mixtures are not properly proportioned; if the materials of which they are proportioned are not properly graded so as to reduce voids to the lowest possible limit; if the mixtures are too dry or too wet; if, after placing, the concrete is not protected against too rapid drying, the resulting structure will not be watertight. Reinforcing steel must be protected against rust and this can be done only when the concrete in which it is embedded is impermeable to water. The fact that many concrete structures have been remodeled, enlarged, or torn down, exposing reinforcing steel that had been embedded for many years effectively protected against rust, shows that the concrete must have been damp-proof. Good concrete practice in all its details is about all that is necessary to insure watertightness of concrete for ordinary purposes.

One of the oldest processes of waterproofing concrete is known as the Sylvester process. It consists of adding alum and soft soap to the concrete when mixed or applying separate solutions of these materials to the concrete surface after it is finished. The principle of their effectiveness is due to the fact that chemical compounds are formed that fill the pores of the concrete with an insoluble material.

Asphalt and coal-tar are sometimes used for waterproofing, particularly as applied to the outside of foundation or basement walls. They are applied hot with a mop. Several coats are usually given. The illustrations on page 59 show methods of waterproofing. Extra precautions should be taken to cover all corners thoroughly.

Failure to make some classes of construction waterproof can be remedied by various after-treatments. If leakage from a cistern or tank consists merely of slight seepage through the walls, a coat of cement mortar may be applied to the interior of the tank. The surface must be thoroughly cleansed by scrubbing it with water and a good stiff wire brush. If scrubbing will not clean the surface, then the cement film should be removed by applying a wash of one part muriatic acid to three or four parts of water, allowing this to remain for a very few moments and then *thoroughly* rinsing with clean water. Immediately before applying the plaster coat the cleansed surface should be painted with cement and water mixed to the consistency of cream. This can be applied with an ordinary brush and the plaster should be spread on immediately and worked in place vigorously before this wash has commenced to harden. Plastering will not remedy cracking due to deficient and ineffective reinforcement. The only way to repair such a structure is to use the old tank as a form and build a new reinforced concrete lining within it. Another method used to repair leaky tank walls where seepage is due to porous concrete resulting from poor workmanship is to fill the pores by applying a solution of what is commonly known as water-glass. This chemical can be obtained at any drug-store. To apply it, one part water-glass is added to three or four parts of water, and several coatings painted on at intervals of twenty-four hours until the pores in the surface have been filled.

Cracks Can be Repaired

Cracks in tanks, troughs, or cistern walls can be repaired by cutting out each side of the crack to form a "V"-shaped groove, one and one-half inches deep and about one inch wide, at the surface. If the reinforcement can be depended upon to prevent the crack opening any wider, this groove can be calked with oakum soaked in tar until about half of the groove depth is filled, when the remainder is filled with a 1:2 cement mortar; or, after having calked the bottom of the crack with oakum soaked in tar, a plastic mixture consisting of pine tar and Lehigh Portland cement, combined in proportion so as to make a paste as stiff as can be conveniently handled, should be worked into the groove until it has been filled. This preparation may tend to harden slightly while being used, but can be kept sufficiently plastic by subjecting it to moderate heat in the metal receptacle in which it is mixed.

Surface Finish of Concrete

CONCRETE possesses the advantage of manipulation to secure readily a great variety of surface finishes. Some of these finishes are given entirely after the work has been completed. Others are partly arranged for when the materials are selected.

The simplest form of surface finish is that secured by placing the concrete in well-made regular forms and spading next to form faces so that a film of cement-sand mortar will lie next to the surface. This has a somewhat monotonous appearance, and whatever color may be in evidence is due almost entirely to the cement. The sand does not affect the color of the surface to any extent because the particles are covered with a film of cement. If forms have been well made, the only treatment that is necessary to give to such a natural surface is to patch up small imperfections, using a mortar of the same proportions of cement and sand as the mortar of the concrete. Afterward this is rubbed smooth and even by using a wooden float while the surface is kept wet. If the whole surface or object is gone over in this manner, a fairly good finish can be secured at little expense. The surface will be as smooth as the forms in which the concrete was placed, and will also be dense and watertight.

Another finish is secured by floating the surface with carborundum stone while the surface is kept wet. The earlier the surface is rubbed after form removal, the easier it is to eliminate inequalities due to grain markings of wood and joints of sheathing, etc. Rubbing fills surface pores and small cavities. Usually hair cracking is prevented by this treatment.

By far the most attractive finishes that can be given to concrete are those which are in large part prearranged when mixing the materials. Selected aggregates are chosen principally because of their color, as well as for their ability to take polish. White sand, marble chips, granite screenings, crushed feldspar, mica and mica spar, crushed slag, garnet sand, and similar colored rock materials are used. Mixtures are prepared and placed in the usual way. The surface finish is obtained by washing off the film of cement that coats the particles, thus exposing them in the surface of the concrete and in that way revealing their color. If the forms are removed within twenty-four hours after placing concrete, it is usually possible to wash off the surface film of cement by merely scrubbing the surface of the object with a stiff bristle brush kept wet with water. If the concrete has become too hard to yield to this treatment, then an acid wash is used. This usually consists of one part common muriatic acid to three or four parts of water. This wash is applied with a brush, the surface meanwhile being scrubbed lightly until the film of cement has been removed. Immediately afterward the surface of the object must be *quickly and thoroughly washed with clean water* so that all trace of acid will be removed and its further action prevented, otherwise some of the aggregate particles will be loosened from the surface.

Variations of Color

Variations in color and texture of surfaces which are to be secured by washing or otherwise exposing the aggregate are almost numberless. They are limited only by the number of combinations that can be made using the materials at hand. For instance, a mixture of yellow and of white marble chips, or a mixture of gray granite screenings and black crushed slag, with a little mica spar or mica, are examples of possible variations. Such mixtures produce a beautiful surface texture when the film of cement is removed by scrubbing either with water or the acid solution, depending upon the age of the concrete.

Another method of finishing a concrete surface is to tool it in several ways, just as natural stone is cut. If the surface is to be treated in this way, particular attention must be paid to selecting the aggregates, and still greater attention to proportioning the concrete mixtures so that there is certain to be enough cement to fill all the voids or air spaces and firmly to bond all particles so tooling will not dislodge them. Concrete that is to be tooled must be older (harder) than where other methods of surface finishes are used. Aggregates used should be of uniform hardness. Broken stone instead of pebbles are best because of the variation of hardness of natural pebbles.

The degree of polish that can be obtained upon a concrete surface depends upon the thorough grading of the mixture.

Addition of Coloring-matter

Another variation possible in concrete surfaces is secured by adding coloring-matter to the cement. This method can be combined with selected aggregates. For example, if a uniform reddish tone is desired on the surface, red oxide of iron may be added to the cement and pink or red granite chips used as aggregate along with garnet sand. Such a concrete surface is treated either by scrubbing or by rubbing down with carborundum stone. Coloring may also be accomplished by immersing the object in metallic salts and depending upon oxidization on exposure to atmosphere to complete the effect desired. The sulphates of iron and copper are the ones most used for this method of coloring, and produce results which closely resemble weathered bronze. Other methods of surface finish are described under the discussion of stucco, on pages 117 to 120.

COLORING-MATTER

Dry Material Used	Weight of Dry Coloring-matter to 1 Sack Lehigh Cement		
	½ Pound	1 Pound	2 Pounds
Lamp black	Light slate	Light gray	Blue gray
Prussian blue	Light green slate	Light blue slate	Blue slate
Ultramarine blue	....	Light blue slate	Blue slate
Yellow ochre	Light green	....	....
Burnt umber	Light pinkish slate	Pinkish slate	Dull lavender pink
Venetian red	Slate, pink tinge	Bright pinkish slate	Light dull pink
Chattanooga iron ore	Light pinkish slate	Dull pink	Light terra-cotta
Red iron ore	Pinkish slate	Dull pink	Terra-cotta

In cold weather aggregates and water are readily heated by stoves improvised from sections of old steel smokestack

Concrete in Cold Weather

WITHIN the past five years or more construction practices based on a better understanding of the possibilities of concrete have proved that there is no necessity for suspending or deferring ordinary concrete work because of cold weather.

Naturally, the home worker would not choose winter as the most inviting season to carry on such construction, but if he has time on his hands and certain building requirements to meet, cold weather is no bar. Particularly is this true of foundation work, heavy walls, floors indoors, and the manufacture of concrete products where the building enclosure protects the work.

There is no change in general concreting practice in winter, so far as mixture and methods of placing concrete go. The difference lies in some special preparation of materials, such as heating water and aggregates, and in protecting the work until the concrete has hardened. Materials such as sand and pebbles or broken stone are readily heated by stoves improvised from sections of old steel smokestack, and water may be heated in any convenient receptacle. If steam under pressure is available, water can be heated by discharging steam into barrels filled with water, and steam jets can be introduced into aggregate piles to warm these materials.

The principles necessary to observe may briefly be summarized as follows:

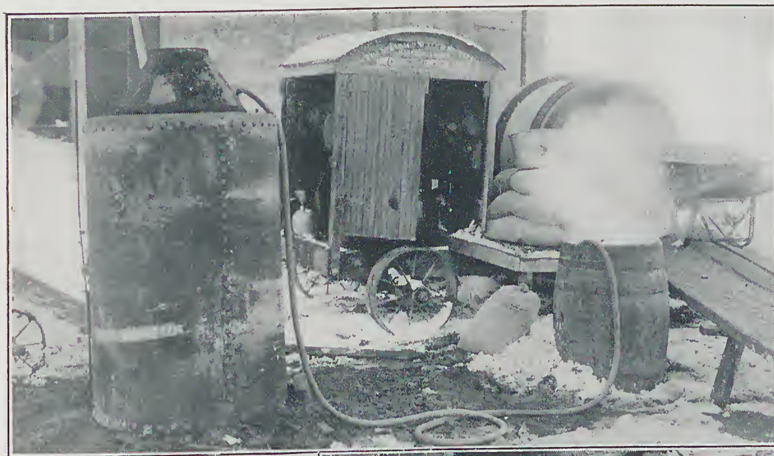
Forms should be free from ice and snow before concrete is placed.

All the materials except cement should be heated so that, immediately after concrete has been mixed, its temperature will not be lower than 80 degrees Fahrenheit.

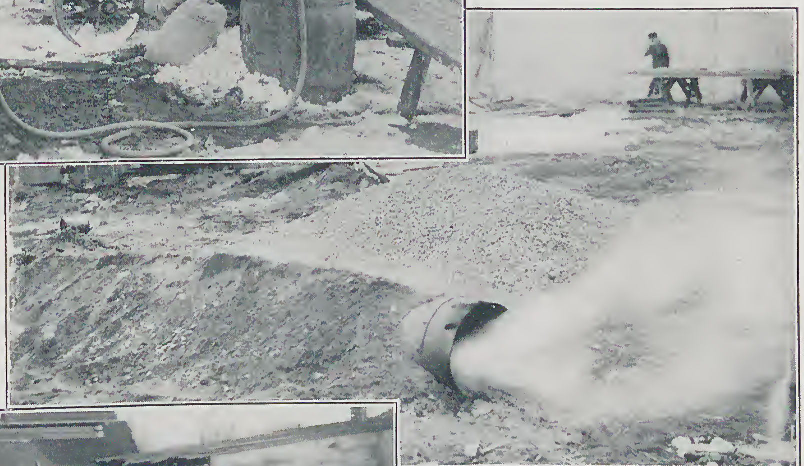
As soon as possible after mixing the concrete should be placed in forms.

All work on the job should be speeded up. Immediately after placing, steps must be taken to provide proper protection against actual freezing of the concrete. It is well known that heat hastens the hardening of concrete and that cold retards it.

When prevailing temperatures are in the neighborhood of 38 degrees Fahrenheit, the hardening of concrete is practically suspended. At the freezing-point (32 degrees) it ceases entirely. A variety of methods can be used to protect the concrete. These should be such as to keep the concrete as nearly at 60 degrees Fahrenheit as possible over a period of at least two days. At the end of this time

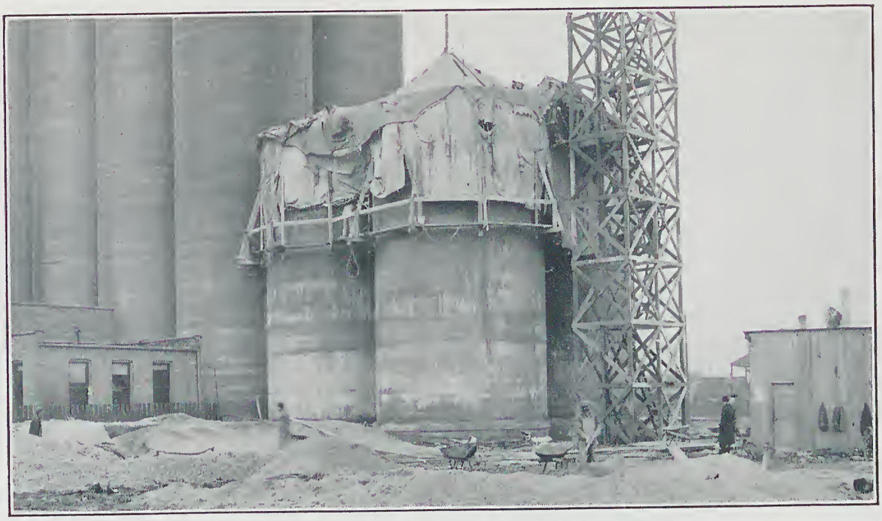


WINTER CONCRETE
Steam to heat the mixing water and rid the forms and aggregates of ice



WINTER CONCRETE
An old stack serves as a heater for sand and stone

WINTER CONCRETE
Lengthening the building season keeps the organization intact and affords earlier use of completed structure. Salamanders shown below are useful to maintain working temperature



Canvas covering raised as the work progressed

hardening will have progressed far enough to render it proof against injury from freezing.

Frozen concrete should not be mistaken for naturally hardened concrete.

Forms should not be removed from concrete work done in cold weather until it is positively known that the concrete will be self-supporting, or if it is to be exposed to loads other than its own weight, has acquired sufficient strength.

Salamanders or coke-burning stoves will maintain the required temperature. Where the work is not enclosed, canvas or building paper fastened to frames of studding will provide the necessary housing.

From the contractor's standpoint, the advantages of continuing concrete work during cold weather are that effective labor organizations can be kept intact and the overhead expense of operation distributed over a greater number of months,—perhaps throughout the twelve months,—rather than for a period commonly known as the construction season, which seldom averages more than seven months. From the standpoint of the owner of a building, the advantages are early occupancy and, therefore, opportunity to benefit sooner from the profits of the business. The concrete products plant through winter operation is enabled to accumulate during the season of least demand a supply of products ready for the early spring demand when construction activities commence.

Concrete in Warm Weather

THE protection that should be given to concrete work during hot, dry weather is about the same for all classes of concrete work. Ways and means of applying it may differ slightly, but all aim to prevent the concrete from drying out.

Floors, walks, street and highway pavements may be protected by very simple means. In extremely hot weather it is best to stretch canvas on frames over concrete street and highway pavement immediately after the surafce has been struck off and floated. Then when the concrete has hardened enough so it will not be marked or pitted by covering with earth or other water-retaining material, two inches of this should be evenly spread over the surface. This covering should be sprinkled often enough each day to keep it always moist.

Walls of such structures as concrete silos and water tanks should be protected either by frequent sprinkling or preferably by hanging canvas or burlap over them. The covering as well as the concrete should be sprinkled often. Sometimes, especially when temperatures are not extremely high, sprinkling of the concrete alone, if done at sufficiently frequent intervals, gives the desired protection.

Mass work, such as foundation and walls, can be protected by leaving the forms in place and occasionally sprinkling for several days.

Keep the concrete moist.

Tables of Information

BEARING POWER OF SOILS

	Supporting Power in Tons per Sq. Ft.
Rock—in thick layers, in natural bed	200
Clay—in thick beds, always dry	4
Clay—in thick beds, moderately dry	2
Clay—soft	1
Gravel and coarse sand, well cemented	8
Sand—compact and well cemented	4
Sand—clean and dry	2
Loam soils	0.5

QUANTITY OF LEHIGH

1 cu. ft. concrete	Sacks of Lehigh cement	1 cu. yd. concrete	Bbls. of Lehigh cement
1:1:1	0.5404	1:1:1	3.375
1:1½:3	0.2808	1:1½:3	1.895
1:2:4	0.2220	1:2:4	1.498
1:2½:5	0.1848	1:2½:5	1.247
1:3:6	0.1570	1:3:6	1.060

COMPRESSIVE STRENGTH OF CONCRETE

Strengths given may be expected from concrete made from Lehigh cement and first-class sand and coarse aggregate, for concrete which has been well mixed and cured without drying out.

Mix by volume	Average compressive strength of 6- by 12-inch cylinders (lbs. per sq. in.) at ages of			
	1 month	3 months	6 months	1 year
1:3:6	1200	1700	2000	2400
1:2½:5	1600	2200	2600	3000
1:2:4	2100	2700	3100	3500
1:2:3	2200	2900	3300	3700
1:1½:3	2600	3300	3700	4100

MATERIALS REQUIRED FOR 100 SQUARE FEET OF SURFACE FOR VARYING THICKNESS OF PLASTER

Thickness	Mixture 1:1		Mixture 1:2		Mixture 1:2½		Mixture 1:3	
	Lehigh cement	Sand	Lehigh cement	Sand	Lehigh cement	Sand	Lehigh cement	Sand
Inches	Sacks	Cu. yd.	Sacks	Cu. yd.	Sacks	Cu. yd.	Sacks	Cu. yd.
⅜	2.2	0.08	1.5	0.11	1.3	0.12	1.1	0.13
½	3.0	0.11	2.0	0.15	1.7	0.16	1.5	0.17
¾	4.5	0.16	2.9	0.22	2.5	0.23	2.2	0.25
1	6.0	0.22	3.9	0.29	3.3	0.31	3.0	0.33
1¼	7.5	0.27	4.9	0.36	4.2	0.39	3.7	0.41
1½	9.0	0.33	5.9	0.43	5.1	0.47	4.5	0.50
1¾	10.5	0.39	6.9	0.50	6.0	0.56	5.4	0.60
2	12.0	0.45	7.9	0.58	6.9	0.64	6.2	0.69

If hydrated lime is used, it should be added in amounts of from 5 to 10 per cent. by weight of the cement.
Hair is used in the scratch coat only in amounts of ⅛ bushel to 1 sack of cement.
These figures may vary 10 per cent. in either direction, due to the character of the sand.
No allowance is made for waste.

NUMBER OF SQUARE FEET OF WALL SURFACE COVERED PER SACK OF LEHIGH CEMENT, FOR DIFFERENT PROPORTIONS AND VARYING THICKNESS OF PLASTERING

Proportions of mixture	Materials			Total thickness of plaster				
	Sacks Lehigh cement	Cu. ft. sand	Bushels hair*	½ in.	¾ in.	1 in.	1¼ in.	1½ in.
				Sq. ft. covered	Sq. ft. covered	Sq. ft. covered	Sq. ft. covered	Sq. ft. covered
1:1	1	1	⅛	33.0	22.0	16.5	13.2	11.0
1:1½	1	1½	⅛	42.0	28.0	21.0	16.0	14.0
1:2	1	2	⅛	50.4	33.6	25.2	20.1	16.8
1:2½	1	2½	⅛	59.4	39.6	29.7	23.7	19.8
1:3	1	3	⅛	67.8	45.2	33.9	27.1	21.6

*Used in scratch coat only.

Note.—These figures are based on average conditions, and may vary 10 per cent. either way, according to the quality of the sand used. No allowance is made for waste.

AREA DRAINED BY TILE MAINS

Size of Tile	Fall per 100 Feet							
	1¼ In. or 0.1 Ft.	2⅜ In. or 0.2 Ft.	3⅝ In. or 0.3 Ft.	4¾ In. or 0.4 Ft.	6 In. or 0.5 Ft.	9 In. or 0.75 Pt.	12 In. or 1.0 Ft.	24 In. or 2.0 Ft.
Inches	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
4	3	6	7	8	9	10	13	18
5	7	10	12	14	15	19	23	32
6	12	17	21	24	27	33	38	55
8	26	37	45	60	74	85	106	125
10	50	70	85	100	110	140	195	225
12	86	118	145	165	175	230	265	380
15	152	215	270	310	355	430	500	720
18	250	360	440	515	575	720	820	1150

QUANTITIES OF MATERIALS REQUIRED FOR LINEAR FOOT OF CONCRETE PAVING FOR THE WIDTHS AND THICKNESSES AT SIDES AND CENTER AS LISTED

Width	Thickness Side and Center	Lehigh Cement (bbl.)		Sand (cu. yd.)		Rock or Pebbles (cu. yd.)	
		1:2:3	1:1½:3	1:2:3	1:1½:3	1:2:3	1:1½:3
Feet	Inches						
9	6–7	0.32	0.35	0.10	0.08	0.14	0.16
16	6–8	0.63	0.68	0.19	0.15	0.28	0.30
18	6–8	0.71	0.77	0.21	0.17	0.32	0.34
20	6–8½	0.82	0.90	0.24	0.20	0.36	0.40
24	6–9	1.01	1.10	0.30	0.24	0.45	0.49

Quantities based on the assumption of 45 per cent. voids in the coarse aggregate.

MATERIALS REQUIRED FOR 100 SQUARE FEET OF SURFACE OF VARYING THICKNESS

Mix	Thickness 1 Inch			Thickness 2 Inches			Thickness 4 Inches			Thickness 5 Inches		
	Lehigh Cement	Sand	Stone	Lehigh Cement	Sand	Stone	Lehigh Cement	Sand	Stone	Lehigh Cement	Sand	Stone
1:2	3.9	0.29	..	7.9	0.58	..	..	..	..	..	..	..
1:1:1	4.2	0.15	0.15	8.3	0.31	0.31	..	..	..	..	..	..
1:1:1½	3.7	0.14	0.20	7.3	0.27	0.41	..	..	..	..	..	..
1:1½:2½	2.6	0.14	0.24	5.1	0.28	0.47	..	..	..	..	..	..
1:1½:3	..	..	..	..	..	..	9.4	0.52	1.04	11.7	0.65	1.30
1:2:3	..	..	..	..	..	..	8.6	0.64	0.95	10.8	0.80	1.19
1:2:4	..	..	..	..	..	..	7.4	0.55	1.10	9.3	0.69	1.37
1:2½:4	..	..	..	..	..	..	6.9	0.64	1.02	8.6	0.80	1.27
1:2½:5	..	..	..	..	..	..	6.2	0.57	1.14	7.7	0.72	1.43
1:3:6	..	..	..	..	..	..	5.2	0.58	1.16	6.5	0.73	1.45

Mix	Thickness 6 Inches			Thickness 7 Inches			Thickness 8 Inches			Thickness 9 Inches		
	Lehigh Cement	Sand	Stone	Lehigh Cement	Sand	Stone	Lehigh Cement	Sand	Stone	Lehigh Cement	Sand	Stone
1:1½:3	14.0	0.78	1.56	16.4	0.91	1.82	18.7	1.04	2.08	21.1	1.17	2.34
1:2:3	12.9	0.95	1.43	15.0	1.11	1.67	17.2	1.27	1.90	19.3	1.43	2.14
1:2:4	11.1	0.82	1.64	12.9	0.96	1.92	14.8	1.10	2.19	16.7	1.23	2.47
1:2½:4	10.3	0.95	1.53	12.0	1.11	1.78	13.8	1.27	2.03	15.5	1.43	2.29
1:2½:5	9.2	0.86	1.72	10.8	1.00	2.00	12.3	1.14	2.29	13.9	1.29	2.57
1:3:6	7.9	0.87	1.74	9.2	1.02	2.03	10.5	1.16	2.32	11.8	1.31	2.61

Note.—Quantities expressed in the following units: Cement—sacks; sand—cubic yards; pebbles or broken stone—cubic yards.

MATERIALS REQUIRED FOR 100 SQUARE FEET OF SIDEWALKS AND FLOORS OF VARYING THICKNESSES

Thickness	Concrete base											
	Mixture 1:2:3			Mixture 1:2:4			Mixture 1:2½:4			Mixture 1:2½:5		
	Lehigh cement	Sand	Stone	Lehigh cement	Sand	Stone	Lehigh cement	Sand	Stone	Lehigh cement	Sand	Stone
Inches												
2½	5.4	0.40	0.60	4.6	0.34	0.68	4.3	0.40	0.63	3.9	0.36	0.72
3	6.5	0.48	0.72	5.6	0.41	0.82	5.2	0.48	0.77	4.6	0.43	0.86
3½	7.5	0.56	0.84	6.5	0.48	0.96	6.0	0.56	0.89	5.4	0.50	1.00
4	8.6	0.64	0.95	7.4	0.55	1.10	6.9	0.64	1.02	6.2	0.57	1.14
4½	9.7	0.72	1.07	8.3	0.62	1.23	7.7	0.72	1.14	6.9	0.64	1.28
5	10.8	0.80	1.19	9.3	0.69	1.37	8.6	0.80	1.27	7.7	0.71	1.43
5½	11.8	0.88	1.31	10.2	0.76	1.50	9.5	0.87	1.40	8.5	0.78	1.57
6	12.9	0.96	1.43	11.1	0.82	1.64	10.3	0.95	1.53	9.2	0.86	1.72

TOP FINISH FOR SIDEWALKS AND FLOORS

Thickness	Mixture 1:1		Mixture 1:1½		Mixture 1:2	
	Lehigh cement	Sand	Lehigh cement	Sand	Lehigh cement	Sand
Inches						
½	3.0	0.11	2.4	0.13	2.0	0.15
¾	4.5	0.16	3.6	0.19	2.9	0.22
1	6.0	0.22	4.8	0.26	3.9	0.29
1¼	7.5	0.27	6.0	0.33	4.9	0.36
1½	9.0	0.33	7.2	0.40	5.9	0.43
1¾	10.5	0.39	8.4	0.46	6.9	0.50
2	12.0	0.45	9.6	0.53	7.9	0.58

Note.—Quantities expressed in the following units: Cement—sacks; sand—cubic yards; pebbles or broken stone—cubic yards.

MIXTURES FOR BODY OF CONCRETE BLOCK

Proportions for body of block	Cu. ft. of sand and stone per bbl. of Lehigh cement			Quantities of materials necessary for 1 cu. yd. of concrete			Quantities of materials necessary for one hundred 8″ x 8″ x 16″ standard concrete block, allowing 33 per cent for air chambers		
	Bbl. of Lehigh cement	Cu. ft. sand	Cu. ft. stone	Bbl. of Lehigh cement	Cu. yd. sand	Cu. yd. stone	Bbl. of Lehigh cement	Cu. yd. sand	Cu. yd. stone
1:2:4	1	8	16	1.51	0.45	0.89	2.20	0.66	1.30
1:2½:4	1	10	16	1.39	0.51	0.82	2.04	0.75	1.20
1:2½:5	1	10	20	1.24	0.46	0.92	1.81	0.68	1.35
1:3	1	12	..	2.25	1.00	..	3.30	1.46	..

MIXTURES FOR FACING OF CONCRETE BLOCK

Proportions for facing	Cu. ft. of sand per bbl. of Lehigh cement		Quantities of materials necessary for 1 cu. yd. of concrete		Quantities of materials necessary for one hundred 8″ x 8″ x 16″ standard block	
	Bbl. of Lehigh cement	Cu. ft. of sand	Bbls. of Lehigh cement	Cu. ft. of sand	Bbl. of Lehigh cement	Cu. ft. of sand
*1:1½	1	6	3.86	23.2	0.53	3.20
*1:2	1	8	3.10	25.1	0.43	3.45

* Based on facing used in surface layer ½″ thick.

Estimating Tables and Examples of Use

FOR convenience, concrete is usually mixed in batches. The first column shows the indicated mix. Columns two, three, and four give the proportions in terms of sacks and cubic feet. The fifth and sixth columns show the quantity of mortar and concrete resulting from the various mixtures made in batches, each containing one sack of Lehigh cement. The last three columns give the quantities of materials necessary to produce one cubic yard of mortar and concrete of different proportions.

QUANTITIES OF MATERIALS

Mixtures	Materials			Quantities from One-Sack Batches		Quantities for 1 Cu. Yd. of Mixed Material		
	Lehigh Cement in Sacks	Sand	Pebbles or Stone	Mortar	Concrete	Lehigh Cement in Sacks	Sand	Pebbles or Stone
		Cu. ft.	Cu. ft.				Cu. ft.	Cu. ft.
1 : 1½	1	1.5	. .	1.75	. .	15.5	23.2	. .
1 : 2	1	2.0	. .	2.1	. .	12.8	25.6	. .
1 : 3	1	3.0	. .	2.8	. .	9.6	28.8	. .
1 : 1½ : 3	1	1.5	3	. .	3.5	7.6	11.4	22.8
1 : 2 : 3	1	2.0	3	. .	3.9	7.0	14.0	21.0
1 : 2 : 4	1	2.0	4	. .	4.5	6.0	12.0	24.0
1 : 2½ : 4	1	2.5	4	. .	4.8	5.6	14.0	22.4
1 : 2½ : 5	1	2.5	5	. .	5.4	5.0	12.5	25.0
1 : 3 : 5	1	3.0	5	. .	5.8	4.6	13.8	23.0
1 : 3 : 6	1	3.0	6	. .	6.4	4.2	12.6	25.2

EXAMPLE I.—How much cement, sand, and pebbles will be required to build a feeding floor 30 by 24 feet, 5 inches thick?

Multiplying the area (30 by 24) by the thickness in feet gives 300 cubic feet, and dividing this by 27 gives $11\frac{1}{9}$ cubic yards as the required volume of concrete. A one-course floor should be of 1 : 2 : 3 mixture. The table shows that each cubic yard of this mixture required 7 sacks of cement, 14 cubic feet of sand, and 21 cubic feet of gravel or stone. Multiplying these quantities by the number of cubic yards required ($11\frac{1}{9}$) gives the quantities of material required (eliminating fractions) as 78 sacks of cement, 156 cubic feet of sand, and 233 cubic feet of pebbles or stone. As there are 4 sacks of cement in a barrel, and 27 cubic feet of sand or pebbles in a cubic yard, we shall need a little less than 20 barrels of cement, 6 cubic yards of sand, and 9 cubic yards of pebbles or stone.

EXAMPLE II.—How many fence posts 3 by 3 inches at the top, 5 by 5 inches at the bottom, and 7 feet long can be made from 1 sack of cement? How much sand and pebbles will be needed?

Fence posts should be of a 1 : 2 : 3 mixture. The table shows the volume of a one-sack batch of this mixture to be $3\frac{9}{10}$ cubic feet. The volume of 1 concrete post, found by multiplying the length by the average width and breadth in feet (7 by ⅓ by ⅓), is $\frac{7}{9}$ cubic foot. By dividing $3\frac{9}{10}$ by $\frac{7}{9}$ we find that 5 posts can be made from 1 sack of cement when mixed with 2 cubic feet of sand and 3 cubic feet of pebbles.

EXAMPLE III.—What quantities of cement, sand, and pebbles are necessary to make 100 unfaced concrete blocks, each 8 by 8 by 16 inches?

The product of height, width, and thickness, all in feet (⅔ by ⅔ by $\frac{4}{3}$), gives $\frac{16}{27}$ cubic foot as the contents of a solid block. As the air space is usually estimated as 33⅓ per cent, the volume of concrete in one hollow block will be ⅔, or $\frac{16}{27}$ or $\frac{32}{81}$ cubic foot; in 100 blocks the volume of concrete will be $\frac{3200}{81}$ or 39½ cubic feet, which, being divided by 27, gives a little less than 1½ cubic yards. Unfaced concrete block should be of 1 : 2½ : 4 mixture. The table shows that each cubic yard of this mixture requires $5\frac{6}{10}$ sacks of cement, 14 cubic feet of sand, and $22\frac{4}{10}$ cubic feet of pebbles. Multiplying these quantities by the number of cubic yards required (1½) gives the quantities of material required as $8\frac{2}{5}$ sacks of cement, 21 cubic feet of sand, and $33\frac{3}{5}$ cubic feet of gravel.

EXAMPLE IV.—How many six-foot hog troughs 12 inches wide and 10 inches high can be made from 1 barrel of cement?

Use a 1 : 2 : 3 mixture. The table shows the volume of a one-sack batch of this mixture to be $3\frac{9}{10}$ cubic feet. As there are 4 sacks in 1 barrel, a barrel of cement would be sufficient for 4 times $3\frac{9}{10}$, or $15\frac{6}{10}$ cubic feet of concrete. The product of the 3 dimensions, all in feet, gives the volume of 1 trough as 5 cubic feet. However, approximately 30 per cent of this volume is in the open water basin or inside of the tank, leaving $3\frac{5}{10}$ cubic feet as the solid contents of concrete in 1 trough. Dividing $15\frac{6}{10}$ by $3\frac{5}{10}$, we find that 4 troughs (and a fraction) can be made from 1 barrel of cement when mixed with 8 cubic feet of sand and 12 cubic feet of pebbles, the sides to be 3″ thick and the bottom 4″ thick.

These examples can be used to advantage in figuring other problems.

The History of Lehigh Cement

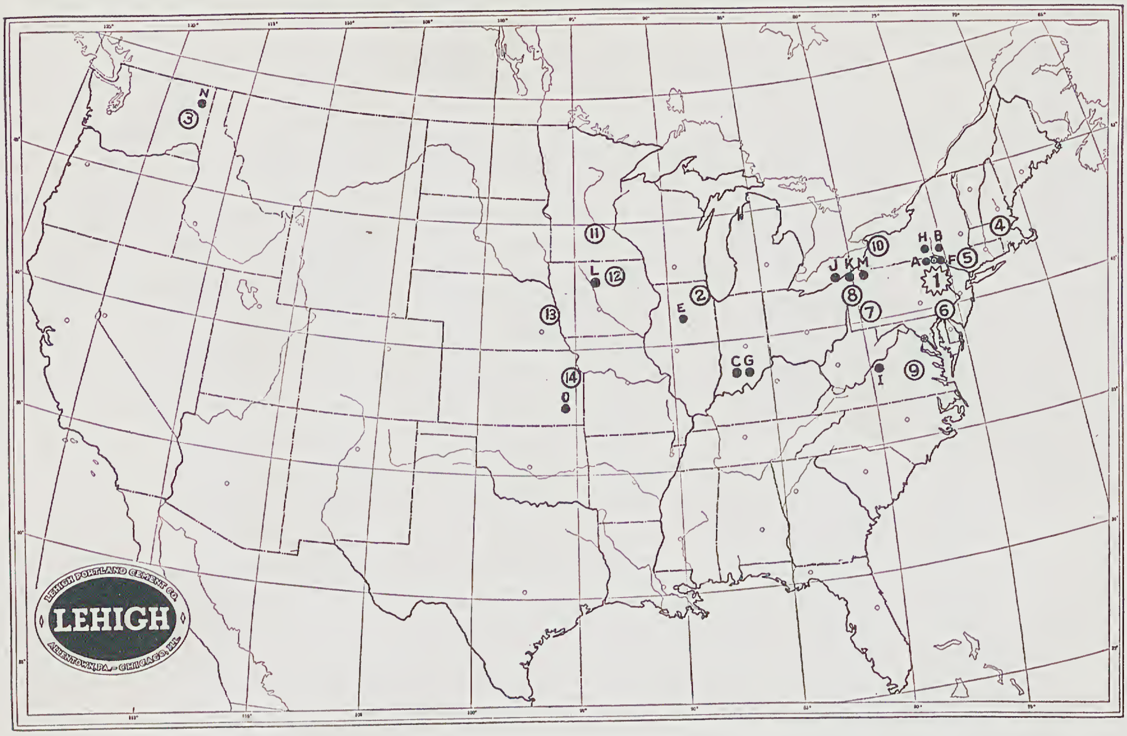
IN THE early fall of 1897 a dozen far-sighted business men in the city of Allentown organized a company to manufacture Portland cement. Gen. Harry C. Trexler, himself the leading farmer in Lehigh County and a close student of the farmers' problems, was chosen to head the new company, and the first mill completed during 1898 was located on what was then known as the Weaver Farm, in Lehigh County, Pennsylvania. This location, in the historic valley of the Lehigh River, caused the new company to be called the Lehigh Portland Cement Company—a name destined to become known from coast to coast as representing the highest standards of cement manufacture and of just and equitable business dealings.

The demand for Lehigh cement soon exhausted the capacity of the first small mill, with its annual production of 200,000 barrels. Accordingly, other mills were established from time to time throughout the State, until now the company operates eight mills in Pennsylvania alone—three at Ormrod, a town near Allentown, named in honor of one of the original directors; one at West Coplay; one at Fogelsville; and three at New Castle. These eight mills have a combined capacity of 21,000 barrels a day—making as much cement in a day as the original mill did in a month.

The vast agricultural development of the West created a further demand for Lehigh cement. Following its policy of establishing mills as close to the user as practicable, the company added to its facilities from time to time to keep pace with this development. As a result it now operates two mills at Mitchell, Ind., as well as mills at Oglesby, Ill., Mason City, Ia., Iola, Kan., Metaline Falls, Wn., and Fordwick, Va.

By this natural growth a chain of Lehigh mills to-day extends from coast to coast, affording the industrial and agricultural districts of the country sources of supply close at hand, thus offering a national service that merits for Lehigh the designation "*The National Cement.*"

It is interesting to note that the Lehigh Company, so modestly begun and now grown to a great national organization, preserves the "family" nature of its ownership. Gen. Trexler still occupies the President's chair, and his associate officers are substantially those elected at the first meeting of the board. Its steady growth has been inspired by careful manufacture, conservative management, and progressive salesmanship, and characterized by relationships founded on broad principles of mutual respect and understanding. To-day, after a quarter-century of constructive service, it is prepared better than ever to co-operate, through its great mills and its thousands of dealers, in the further development of the nation, and looks forward to the coming years with a faith and confidence bred of a readiness to be of ever-increasing service to American enterprise.



OFFICES

1 Allentown, Pa.
2 Chicago, Ill.
3 Spokane, Wn.
4 Boston, Mass.
5 New York City
6 Philadelphia, Pa.
7 Pittsburgh, Pa.
8 New Castle, Pa.
9 Richmond, Va.
10 Buffalo, N. Y.
11 Minneapolis, Minn.
12 Mason City, Iowa
13 Omaha, Neb.
14 Kansas City, Mo.

MILLS

A Ormrod No. 1, Pa.
B West Coplay, Pa.
C Mitchell No. 1, Ind.
D Ormrod No. 2, Pa.
E Oglesby, Ill.
F Ormrod No. 3, Pa.
G Mitchell No. 2, Ind.
H Fogelsville, Pa.
I Fordwick, Va.
J New Castle No. 1, Pa.
K New Castle No. 2, Pa.
L Mason City, Iowa
M New Castle No. 3, Pa.
N Metaline Falls, Wn.
O Iola, Kansas

RAILROADS

Ormrod	Philadelphia & Reading Rwy. Lehigh Valley Railroad Central R. R. of New Jersey
West Coplay	Philadelphia & Reading Rwy. Lehigh Valley Railroad Central R. R. of New Jersey
Chapman	Philadelphia & Reading Railway
Mitchell	Baltimore & Ohio Railroad Chicago, Indianapolis & Louisville Rwy.
New Castle	Baltimore & Ohio Railroad Western Allegheny Buffalo, Rochester & Pittsburgh Rwy. Erie Railroad Pittsburgh & Lake Erie Railway Pennsylvania Company
Fordwick	Chesapeake & Ohio Rwy.
Metaline Falls	Chicago, Milwaukee & St. Paul Railway
Oglesby	Chicago & Northwestern Rwy. Chicago, Burlington & Quincy Railroad Chicago, Milwaukee & St. Paul Railway Chicago, Rock Island & Pacific Railway Illinois Central Railroad
Iola	Atchison, Topeka & Santa Fe Railway Missouri, Kansas & Texas Railway Missouri Pacific Railroad
Mason City	Chicago & Northwestern Rwy. Chicago, Great Western Railroad Chicago, Milwaukee & St. Paul Railway Chicago, Rock Island & Pacific Railway Minneapolis & St. Louis Railroad

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